Crevice Mining Group LLC

July 15, 2016

Robert M. Cronholm
Environmental Science Specialist
Montana Department of Environmental Quality
Small Miner and Exploration Program
1520 E. 6th Avenue
P.O. Box 200901
Helena, MT 59620-0901

Dear Mr. Cronholm,

Please find enclosed for your consideration this re-submission of the application to explore on private property in Park County, Montana. This application incorporates all the comments received from Montana Department of Environmental Quality (DEQ) to the exploration application submitted on October 16, 2015.

Crevice Mining Group has worked with Pioneer Technical Services, Inc. to address all pertinent issues related to pursuing an environmentally responsible plan of operation during exploration and completing all required remediation following the exploration efforts. Additionally, Crevice Mining Group commits to providing substantial funding for reclamation bonding requirements.

As presently constituted, exploration will be solely undertaken on private property, will be limited to the acreage proposed for permitted disturbance, and will not impact surface water (streams) or groundwater. After exploration is complete, the permitted disturbance will be reclaimed and restored in keeping with present Montana standards.

We appreciated you consideration in regard to this matter.

With Regards,

Mike Werner

Dr. Michael A.Werner, PhD. Min.Met Eng.
Managing Partner
614 South 8th Street (P.O. Box 487)
Livingston, MT 59047

Plan of Operations

Exploration Program
Crevice Mining Project

Crevice Mining Group LLC
614 South 8th Street (P.O. Box 487)
Livingston, MT 59047

Prepared for:
Montana Department of Environmental Quality
Hard Rock Mining Program
Helena, MT 59601

July 2016

Plan of Operations
Exploration Program
Crevice Mining Project

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Prepared by:
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July 2016

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Appendix A : Crevice Mountain Resources and Reserves
- Appendix A.1 : American Innovative Minerals LLC Letter Report for Compliant Reserves
- Appendix A.2 : Geology of the Crevice Mountain Gold Mine, Park County, MT by Alan Branham, CPG #10979 – July 16, 2015

Appendix B : Well and Water Data
- Appendix B.1 : Laubach and Johnson Well Logs
- Appendix B.2 : Surface Water Sample Data
- Appendix B.3 : Rousseau Abstract Surface Water Sample Data

Appendix C : NRCS Custom Soils Report for Potential Land Application Discharge Area

1 INTRODUCTION

Crevice Mining Group LLC (Crevice) proposes to complete an exploration program at Crevice Mountain near Jardine, Montana, located in Park County, Montana (**Figures 1 and 2**). The general site information (reserves, location, description, and site figures) is included in sections 1-5 as introductory sections. Sections 6-16 detail the project scope. This Exploration Plan of Operations outlines the proposed underground development, exploration and sampling program, and ore evaluation program to be conducted at Crevice Mountain. All exploration drift development diamond drilling will be conducted by qualified contractors or Crevice personnel.

The exploration program will be called the "Crevice Exploration Project" and although the exploration decline and surface disturbance for the development rock is located approximately one-half mile to the east, the project is similar in scope to the "Upper Crevice Project," which was permitted by TVX-Mineral Hill Mining under the authority of License No. 00559. Crevice intends this project as a continuation of the exploration conducted by TVX Mineral Hill Inc.

The Crevice Exploration Project is designed as a low-impact program expected to start as soon as practicable (following approval of the exploration permit), run continuously for 18 months, and create 14.0 acres of new surface disturbance near the historic Snowshoe Mine (**Figure 2)**. All disturbance areas will be fully bonded. In the first year of exploration, drilling will take place from surface locations and underground locations, totaling approximately 36,000 feet, and with a planned expenditure of approximately $1.1 million. All surface disturbance will be limited to the Patented Claims (see Section 3) and shown on **Figure 3.** The facility layout is shown in **Figure 5**. Surface drilling will be completed using a standard surface diamond drill (preferably track mounted to reduce impact) and Reverse Circulation (RC) drills on 100-foot centers along the alignment of the proposed exploration road and in selected secondary locations (**Figure 6**).

Additional evaluation of the mineralized zone will also be conducted, in conjunction with a permitted surface drilling program, through an underground diamond drilling program, and by sampling and metallurgical testing of selected mineralized rock. To facilitate the underground drilling program, underground access will be driven to the targeted mineralized zone via the portal and decline shown on **Figure 6.** A ramp driven on a 15% decline will allow drilling access to develop and define the Crevice ore body. Alan Branham (certified professional geologist [CPG] #10979) has recommended that underground drilling be completed on 50-foot centers to adequately characterize potential ore reserves. The ramp will continue on a decline, with supplemental development for ventilation, as shown on **Figure 6**. Mine Development Associates (MDA) of Reno Nevada has indicated that drilling intervals as close as 25 feet may be required to adequately define ore zones for 43-101 classified reserve reports (drilling spacing will be a report requirement and mining risk determination).

This exploration program is intended to determine the continuity of potential ore bodies and attempt to delineate economic ore reserves. If a mineral reserve is identified, and Crevice can justify applying for an operating permit as the project progresses, Crevice may apply for the operating permit.

Figures 7-10 show the various exploration roads and plans (See Section 4). To support the exploration activities, Crevice intends to invest in and construct or lease support facilities at the site as shown on **Figure 10**.

Based upon historic mining and the development of the First Chance Portal by TVX/Mineral Hill Mining, it is anticipated that little, if any, underground water will be encountered. Any water encountered during the exploration work will be contained in a closed-loop circuit, held in temporary underground sumps, and recycled for use in drilling. Ditches and runoff control berms upslope from the disturbed area will be constructed to divert surface runoff, and downslope ditches will collect any runoff water from the disturbed area and route it to a sediment collection pond. Additional Best Management Practices (BMPs) (straw wattles, filter fence, stone check dams, etc.) will be installed where required and/or requested by Montana Department of Environmental Quality (DEQ) as discussed in Section 11, Water Management.

Topsoil will be salvaged, stockpiled, and seeded for use in site reclamation. Waste rock storage areas will be graded and reclaimed concurrently with exploration operations. Because a good portion of the area has been logged, a minimum number of trees will be removed. Crevice will take all appropriate measures to eliminate or mitigate environmental impacts.

2 RESERVES

Although a significant amount of historic drilling has been completed on Crevice Mountain, the historic resource and reserves are not compliant under U.S. security laws, and/or National Instrument 43-101 (national instrument for the Standards of Disclosure for Mineral Projects within Canada), or Joint Ore Reserves Committee (JORC) geologic studies. Resource standards for defining an economic reserve have become more rigorous in terms of quality control, geologic definition, and metallurgical testing. Additional exploration work is required to support a 43-101 feasibility study. **Appendix A-1** includes a letter report from American Innovative Minerals, LLC that validates that Crevice Mountain qualifies as an exploration property. **Appendix A-2** includes a geologic report discussing Crevice Mountain and historic production, exploration history, geochemistry, geophysical surveys, and the geology and potential ore zones.

3 LOCATION, ACCESS, AND SITE BACKGROUND

The Crevice deposit is located in Park County, Montana, northeast of Gardiner and approximately 3 miles southeast of the town of Jardine in the SW ¼ of the NE ¼ of Section 22, T. 9S, R.9E (**Figure 1 and Figure 2**). The Crevice deposit is located on and under numerous patented claims over a number of sections in southern Park County. **Appendix A-2** includes additional information on historic production. The exploration portal site near the Snowshoe Mine portal is accessible via Park County and Forest Service roads from Jardine. Additional exploration roads required to access the project area will be fully bonded under the proposed exploration permit. All surface disturbance will be limited to the patented claims listed below, which are owned or leased by the Crevice Mining Group, LLC as well as the unpatented claims shown on **Figure 3:**

Snowshoe	Mineral Survey #4535
Pratt	Mineral Survey #4902
Venus	Mineral Survey #4538
Kentucky	Mineral Survey #4899
Little Bonanza	Mineral Survey #8869
McCauley	Mineral Survey #5614
George Washington	Mineral Survey #5613
Granite	Mineral Survey #4557
Summit	Mineral Survey #4558
Consolidated Mizpah	Mineral Survey #4559

4 PROJECT DESCRIPTION

The exploration portal will be located on the west side of Crevice Mountain near the historic Snowshoe Mine in the upper reaches of the Malin Creek drainage. The portal is located at an elevation of approximately 8,350 feet, 100 feet below the surface of expression of the Conrad Zone.

The exploration program consists of constructing the first 200 feet of exploration adit to be 12-feet wide by 14-feet high. From this adit a decline will be driven to the south (south 45 degrees east) to the 8,056 feet elevation (**Figure 2 and Figure 6)**. The decline ramp will spiral down through the mineralized zone(s) for the purpose of further characterizing the ore body. All development will be underneath the patented claims and in the mineralized Conrad Zone of the Crevice deposit. Inert waste rock will be placed in a temporary waste rock storage area(s) and/or used as road material to improve access roads surface. Waste rock characterization methods for rock/water chemistry and quality assurance are discussed in Section 11.3, Water Quality.

The 14 acres of new surface disturbance associated with the exploration will be confined to the patented land listed herein and include the following disturbance areas:

- An exploration road totaling 2,800 linear feet and 1.6 acres (**Figure 7** and **Figure 8**).
- A primary (west) waste rock storage area totaling 3.5 acres, a secondary (south) waste rock storage area totaling 1.6 acres, and a north waste rock storage area totaling 4.0 acres (**Figure 11** and **Figure 12**).
- Surface drilling pads totaling 0.3 acres (**Figure 7)**.
- Topsoil stockpile areas totaling 0.6 acres (**Figure 11** and **Figure 12**).
- A proposed Land Application Discharge (LAD) area (if required) totaling 4.5 acres (**Figure 13**). Depending on actual groundwater volume encountered (if any), the LAD area may not be necessary. Surface water collected from waste rock storage areas to manage nitrates may be evaporated from the storage pond, depending on actual runoff collected. Discussions with Orica USA indicate that if blasting is implemented correctly,

nitrates should not be a problem. If analytical testing indicates nitrate levels exceed standard requirements, Crevice will switch to non-nitrate blasting compounds.

- Exploration support facilities, topsoil stockpiles, a sediment control pond, and runoff control measures will be located within the limits of the patented claims.

This exploration program will include the following tasks:

- Construct exploration support facilities (dry, office, and sample prep facilities) at the site. The area is shown on **Figure 5**.
- Doze, stockpile, and seed all topsoil from areas to be disturbed.
- Establish the waste rock storage area(s).
- Grade, repair, install culverts, clear overgrown areas, and improve approximately 1.6 miles of Forest Service Road leading to the county roads. This work will be completed in cooperation with the U.S. Forest Service (Forest Service) and approved under their authority.
- Grade, repair, install culverts, clear overgrown areas, and improve approximately 5.6 miles of county road leading to the exploration portal.
- Level the portal area and establish temporary surface facilities, including a sediment collection pond.
- Construct the portal.
- Construct 200 feet of underground drift (12-feet high x 12-feet wide).
- Construct approximately 25,700 feet of underground decline starting at an elevation of 8,350 feet and descending to 8,056 elevation. Refer to Section 11.1, Underground Water, for a discussion on water management and expected groundwater input based on historic data.
- Conduct approximately 64,000 feet (128 drill holes at 500 feet each) of detailed diamond drilling by way of drilling from the surface along the exploration road alignment and underground along the decline alignment (See Section 10.1).

Figure 14 lists the general construction details. Portable powder and cap magazines (one each) will be temporarily located at a safe distance from all facilities in compliance with federal Mine Safety and Health Administration (MSHA) regulations. Within approximately four weeks of project startup, powder and caps will be placed in underground storage, eliminating the requirements for surface magazines.

5 SITE FIGURES

The site figures are included in this section.

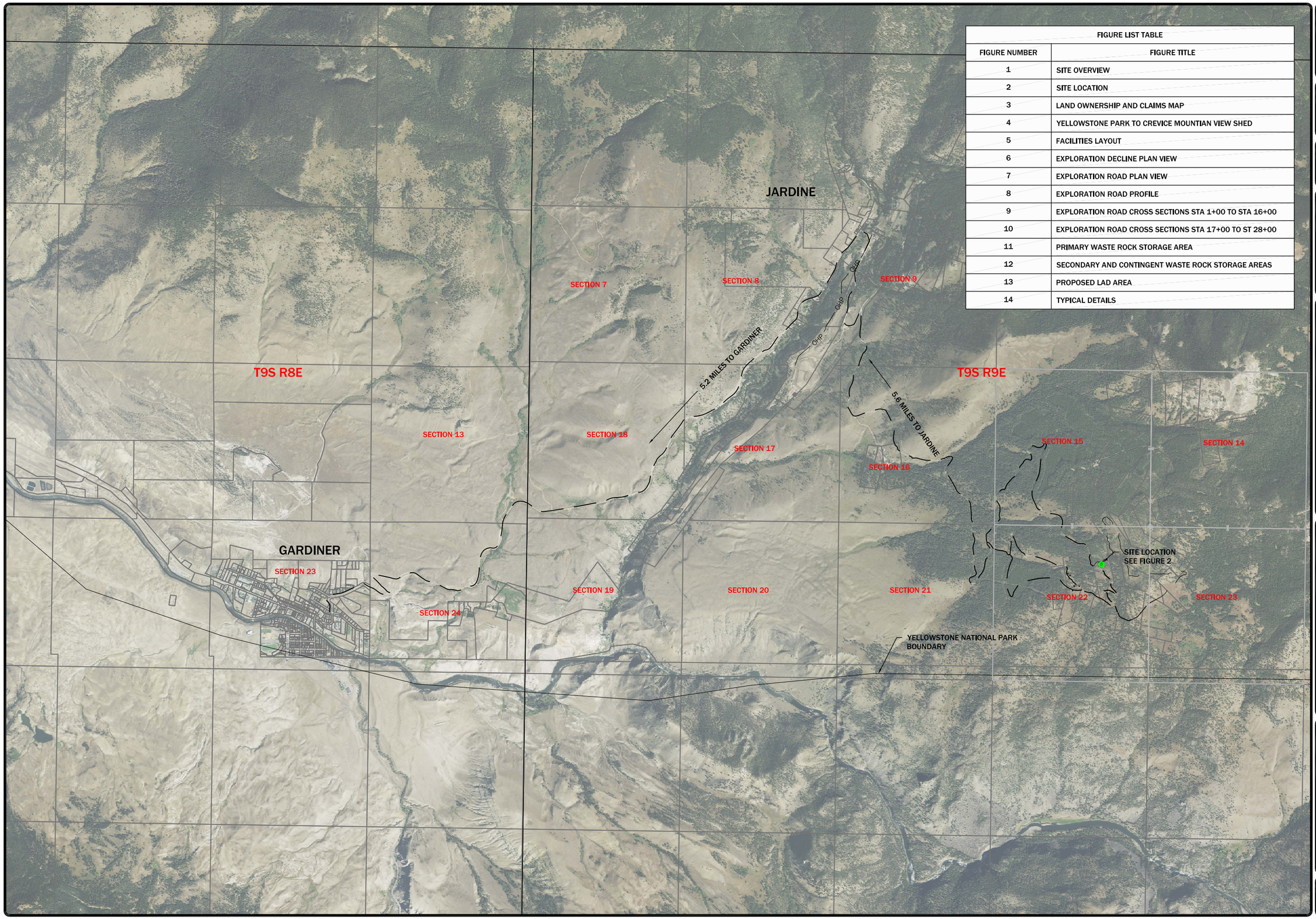

FIGURE LIST TABLE	
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2	SITE LOCATION
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4	YELLOWSTONE PARK TO CREVICE MOUNTIAN VIEW SHED
5	FACILITIES LAYOUT
6	EXPLORATION DECLINE PLAN VIEW
7	EXPLORATION ROAD PLAN VIEW
8	EXPLORATION ROAD PROFILE
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11	PRIMARY WASTE ROCK STORAGE AREA
12	SECONDARY AND CONTINGENT WASTE ROCK STORAGE AREAS
13	PROPOSED LAD AREA
14	TYPICAL DETAILS

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SOURCE: NAIP 2013

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CREVICE MINING GROUP, LLC
CREVICE MOUNTAIN
EXPLORATION PERMIT

SITE
OVERVIEW

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, SUITE C
HELENA, MT 59601
(406) 457-8252

PAGE 6
FIGURE 1

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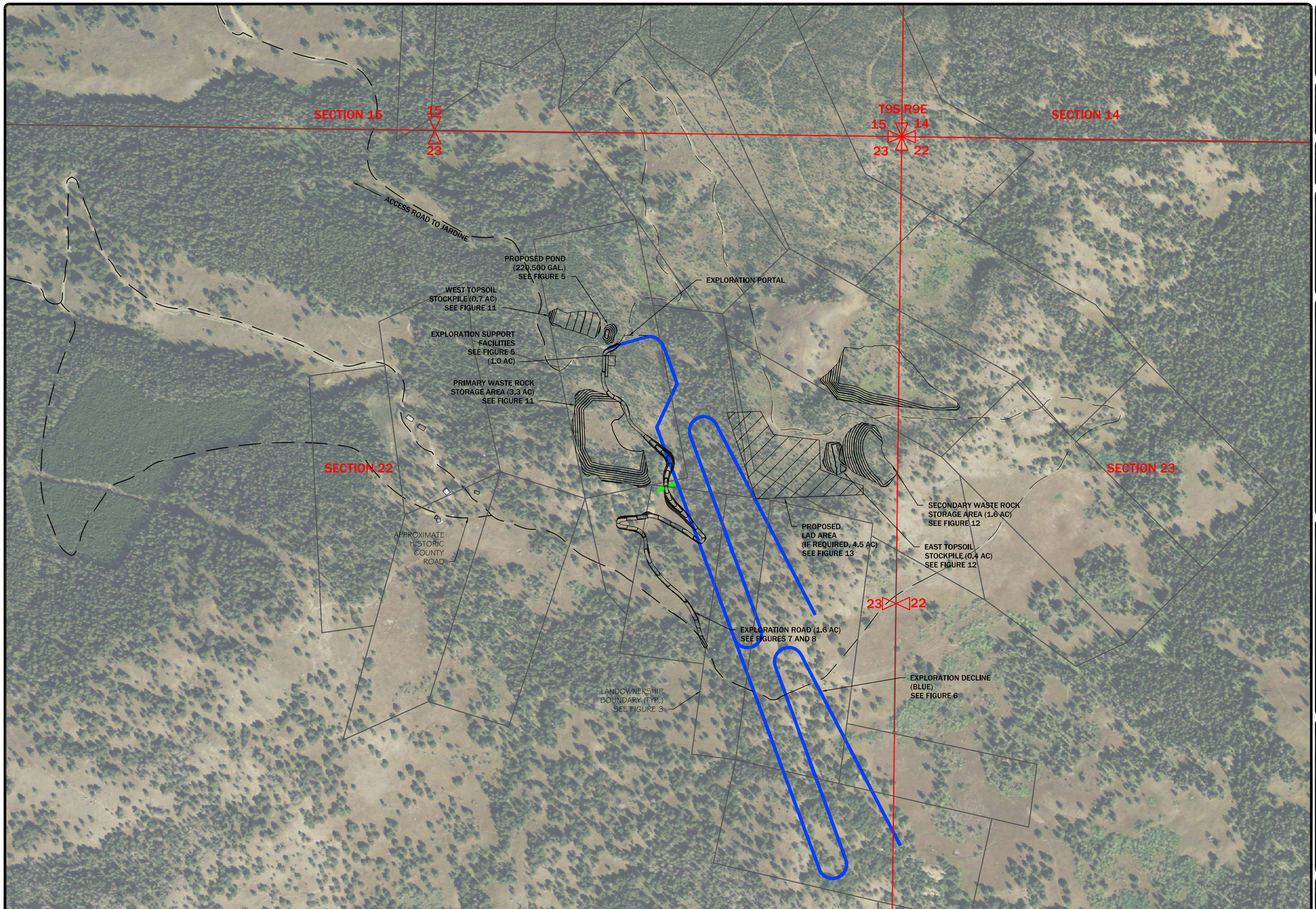

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SITE
LOCATION

PIONEER
TECHNICAL SERVICES, INC.
201 E. BROADWAY, SUITE C
HELENA, MT 59601
(406) 457-8252

PAGE 7
FIGURE 2

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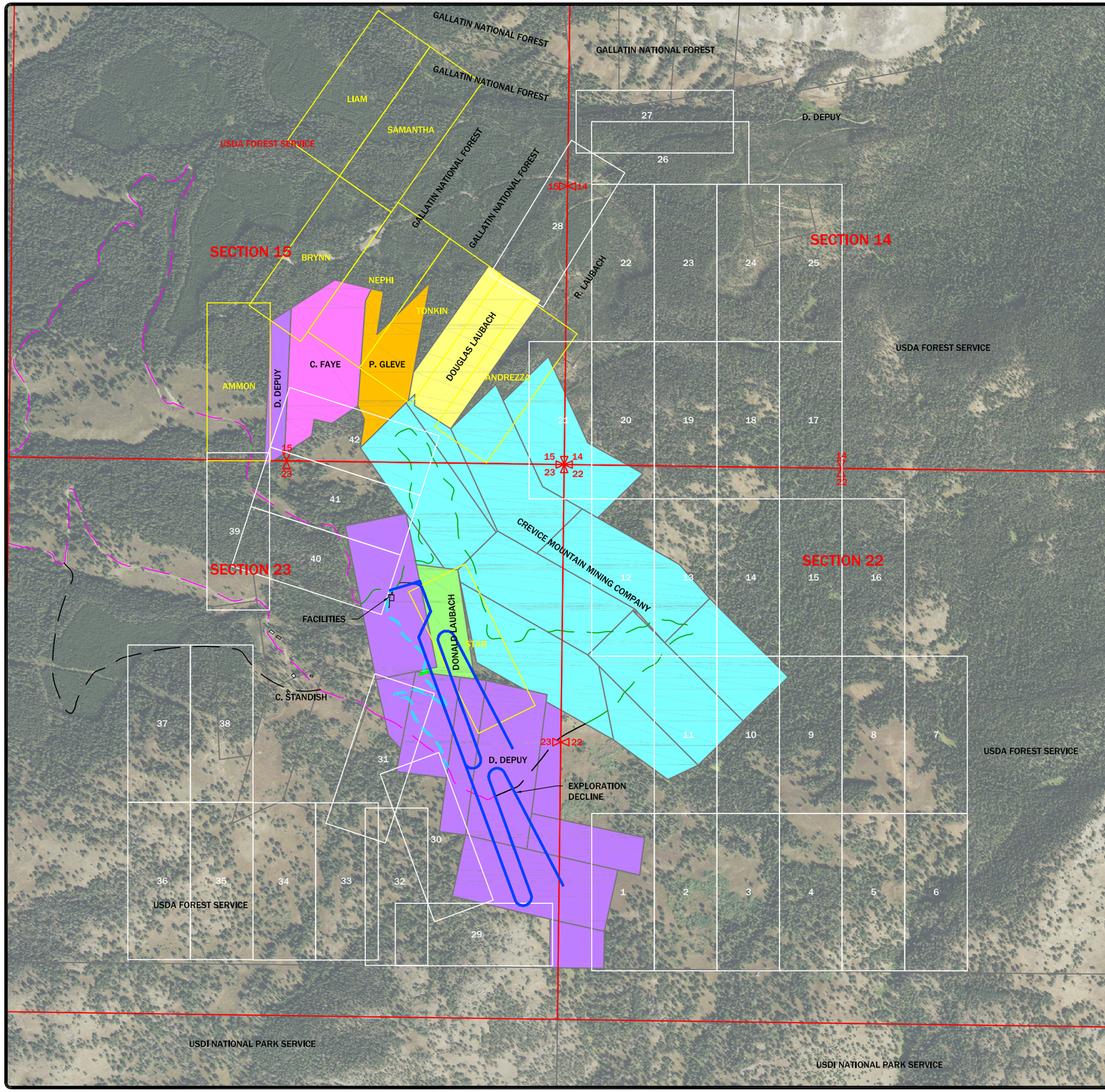

LEGEND:

- EXPLORATION DECLINE
- SECTION
- FACILITY
- COUNTY ROAD
- FOREST SERVICE/PRIVATE ROAD
- PRIVATE ROAD
- EXPLORATION ROAD
- PARCEL BOUNDARY
- COTHRAN, FAYE
- DEPUY, DAVID AND SHIRLEY
- GLEVA, PAUL
- LAUBACH, DONALD AND DEE
- LAUBACH, DOUGLAS AND MARILYN
- CREVICE MOUNTAIN MINING COMPANY
- 2014 UNPATENTED CLAIMS
- 12 2015 UNPATENTED CLAIMS
- SECTION CORNER
- QUARTER CORNER

NOTES:

1. UNPATENTED CLAIMS STAKED IN 2015
   PHASE 1: CLAIMS 39-42
   PHASE 2: CLAIMS 1-38

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CREVICE MINING GROUP, LLC
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LAND OWNERSHIP
AND CLAIMS MAP

PIONEER TECHNICAL SERVICES, INC.
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HELENA, MT 59601
(406) 457-8252

PAGE 8
FIGURE 3

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CREVICE MINING GROUP, LLC
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YELLOWSTONE PARK
TO CREVICE MOUNTAIN
VIEW SHED

PIONEER
TECHNICAL SERVICES, INC.
201 E. BROADWAY, SUITE C
HELENA, MT 59601
(406) 457-8252

PAGE 9
FIGURE 4

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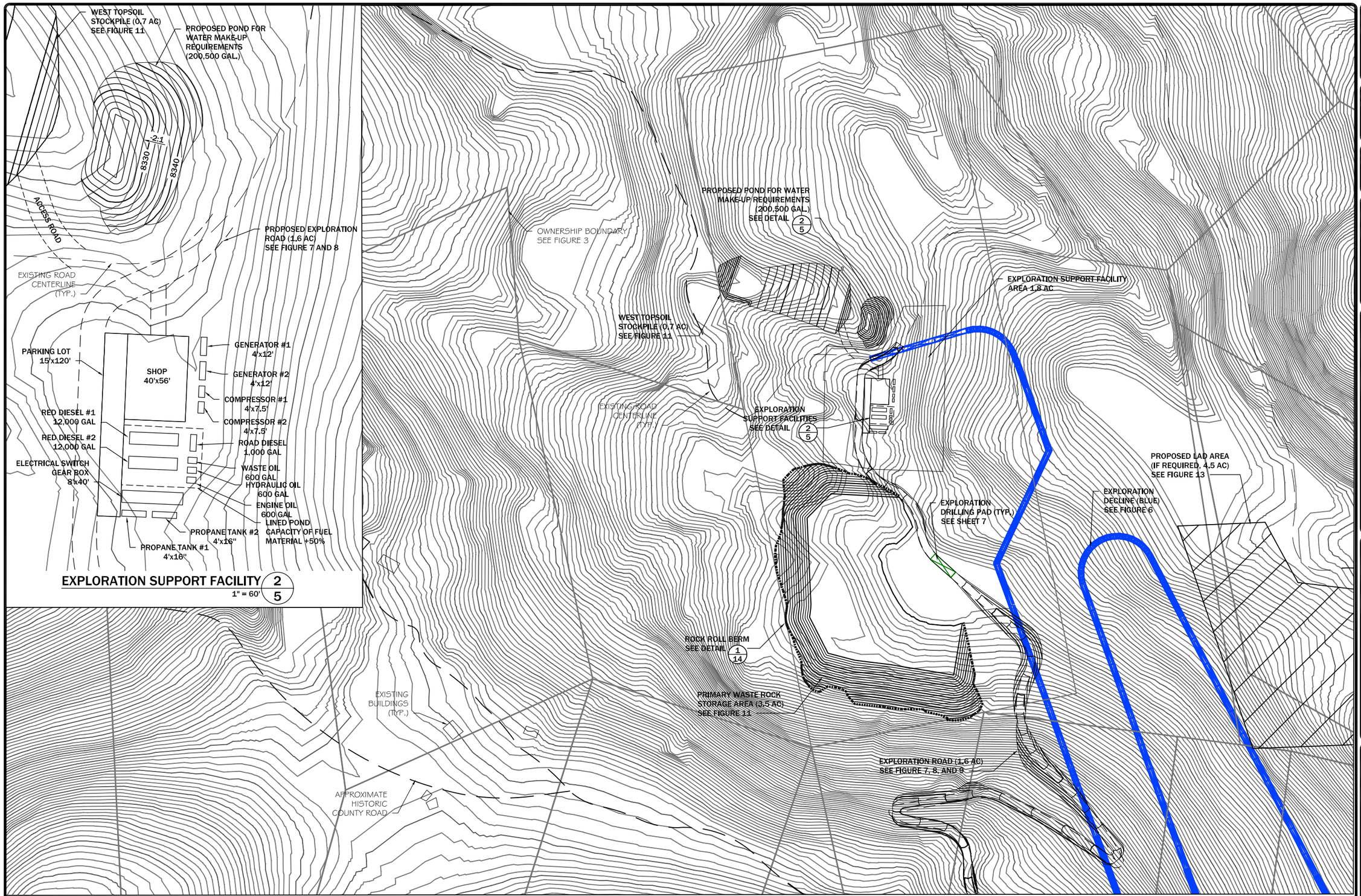

FACILITY OVERVIEW 1/5
1" = 200'

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FACILITIES LAYOUT

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, SUITE C
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PAGE 10
FIGURE 5

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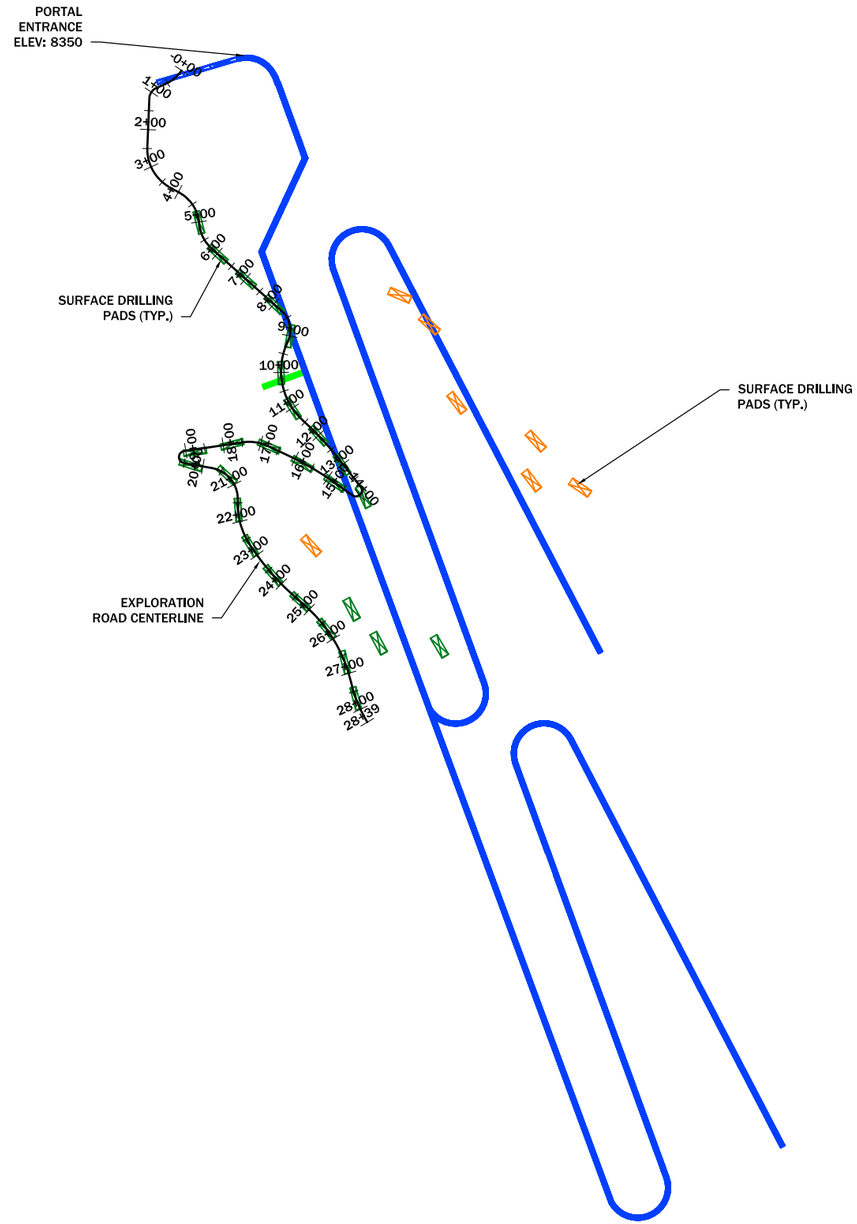
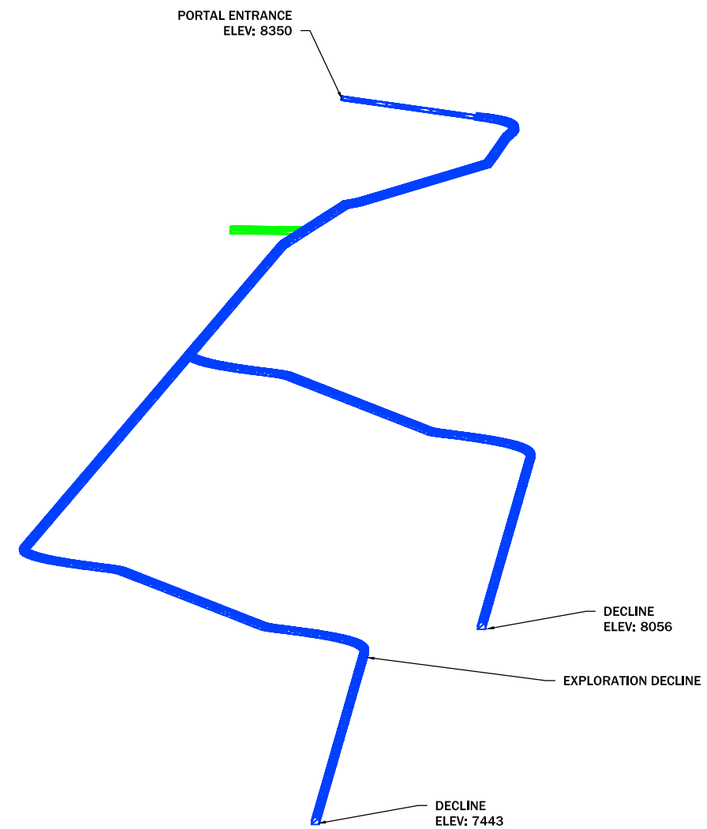


EXPLORATION DECLINE PLAN VIEW 1/6

N.T.S.

LEGEND:

- EXPLORATION DECLINE
- VENTILATION
- SURFACE DRILLING PADS
- SURFACE DRILLING PADS



EXPLORATION DECLINE ISOMETRIC VIEW 2/6

N.T.S.

NOTES:

1. AREAS INDICATED IN BLUE ARE ASSOCIATED WITH THE PROPOSED EXPLORATION PLAN.
2. AS MEASUREMENT FROM OUTCROP, THEORETICAL ORE ZONES INDICATED ABOVE HAVE THE POTENTIAL DOWN DEPTH OF 1000' x 3200'.
3. YEAR ONE EXPLORATION DRILLING WILL INCLUDE APPROXIMATELY 14,000 FEET OF PRIMARY "EXPLORATION" DRILLING ON 100-FOOT CENTERS AND 22,200 FEET OF SECONDARY "DEFINITION" DRILLING ON 50-FOOT CENTERS. THE PLANNED DRILLING APPROACH INCLUDES THE FOLLOWING VARIABLES:
   - STRIKE LENGTH OF MINERALIZED ZONE = 3800'
   - EXPLORATION DRILL HOLES WILL INCLUDE 178 HOLES DRILLED ON 100-FOOT CENTERS AT AN AVERAGE DEPTH OF 78 FEET PER HOLE FOR AT 176 FEET PER HOLE FOR A TOTAL OF 13,728 FEET.
   - DEFINITION DRILL HOLES WILL INCLUDE 74 SECTIONS DRILLED ON 50-FOOT CENTERS AT FOUR HOLES PER SECTION FOR A TOTAL OF 296 DEFINITION HOLES AND 300 FEET TOTAL PER SECTION FOR A TOTAL OF 22,200 FEET.
4. YEAR TWO EXPLORATION AND DEFINITION DRILLING IS BUDGETED FOR AN ADDITIONAL 28,000 FEET OF DRILLING WHICH WILL BE DEFINED BASED ON YEAR ONE DRILLING AND EXPLORATION RESULTS.

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EXPLORATION
DECLINE
PLAN VIEW

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, SUITE C
HELENA, MT 59601
(406) 457-8252

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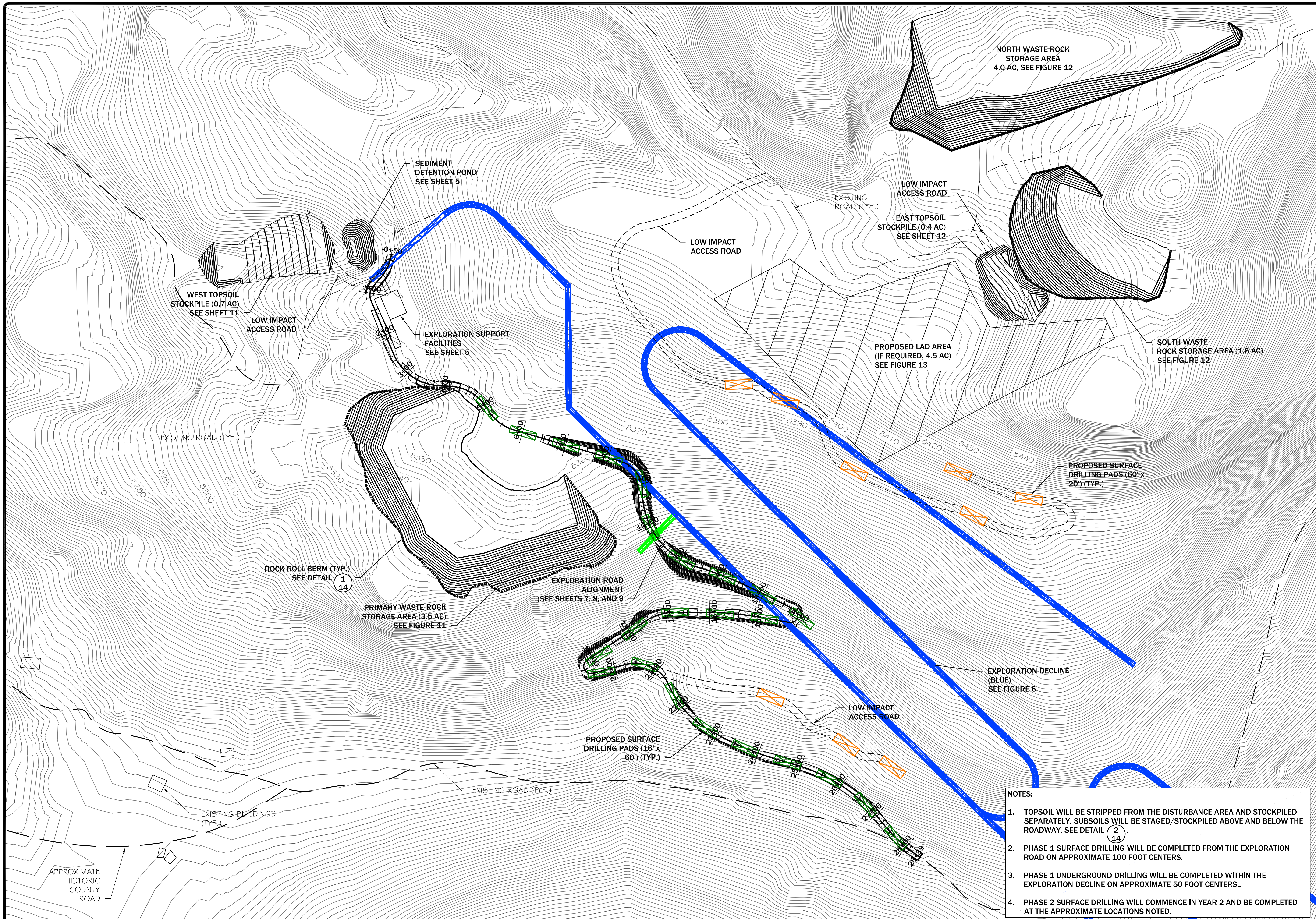

NOTES:

1. TOPSOIL WILL BE STRIPPED FROM THE DISTURBANCE AREA AND STOCKPILED SEPARATELY. SUBSOILS WILL BE STAGED/STOCKPILED ABOVE AND BELOW THE ROADWAY. SEE DETAIL 2/14.
2. PHASE 1 SURFACE DRILLING WILL BE COMPLETED FROM THE EXPLORATION ROAD ON APPROXIMATE 100 FOOT CENTERS.
3. PHASE 1 UNDERGROUND DRILLING WILL BE COMPLETED WITHIN THE EXPLORATION DECLINE ON APPROXIMATE 50 FOOT CENTERS..
4. PHASE 2 SURFACE DRILLING WILL COMMENCE IN YEAR 2 AND BE COMPLETED AT THE APPROXIMATE LOCATIONS NOTED.

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EXPLOATION ROAD PLAN VIEW

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(406) 457-8252

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NOTE:
1. 5' VERTICAL EXAGGERATION

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EXPLORATION ROAD PROFILE

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FIGURE 8

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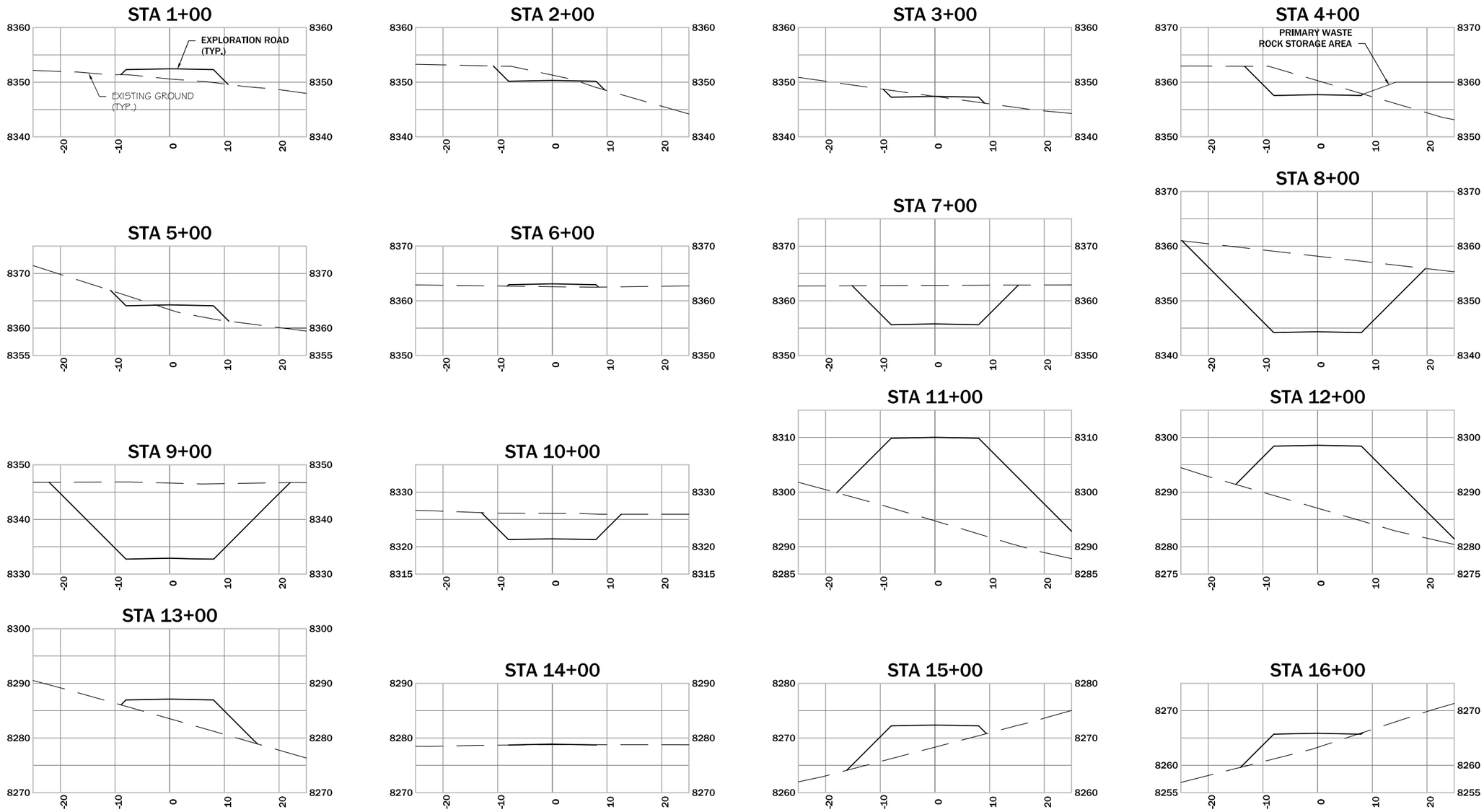

NOTES:

1. SEE DETAIL 2/14 FOR EXPLORATION ROAD DETAILS.
2. TOTAL CUT AND FILL VOLUME BALANCE (ARE EQUAL) FOR THE PROPOSED EXPLORATION ROAD CONSTUCTION.

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SOURCE: CMMG LLC

SCALE IN FEET
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CREVICE MINING GROUP, LLC
CREVICE MOUNTAIN
EXPLORATION PERMIT

EXPLORATION ROAD
CROSS SECTIONS
STA 1+00 TO STA 16+00

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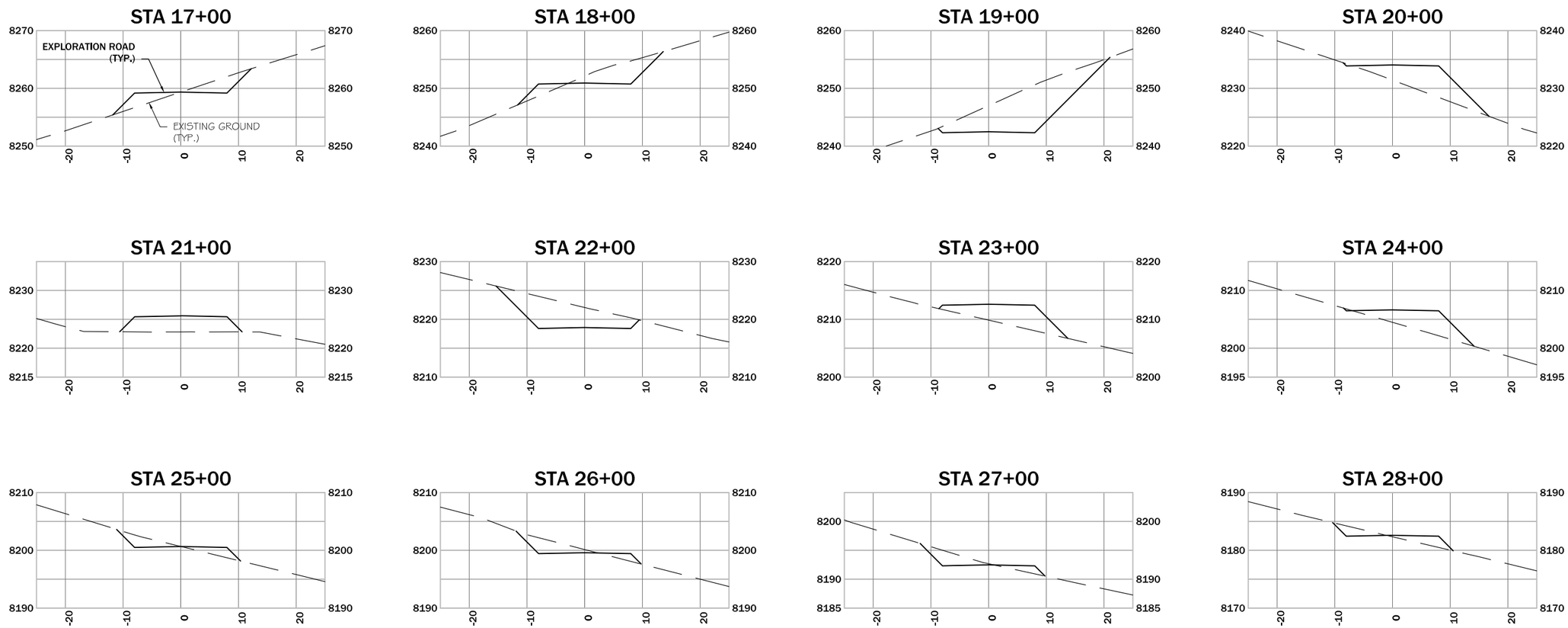

NOTES:

1. SEE DETAIL 2/14 FOR EXPLORATION ROAD DETAILS.
2. TOTAL CUT AND FILL VOLUME BALANCE (ARE EQUAL) FOR THE PROPOSED EXPLORATION ROAD CONSTUCTION.

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CREVICE MINING GROUP, LLC
CREVICE MOUNTAIN
EXPLORATION PERMIT

EXPLORATION ROAD
CROSS SECTIONS
STA 17+00 TO STA 28+00

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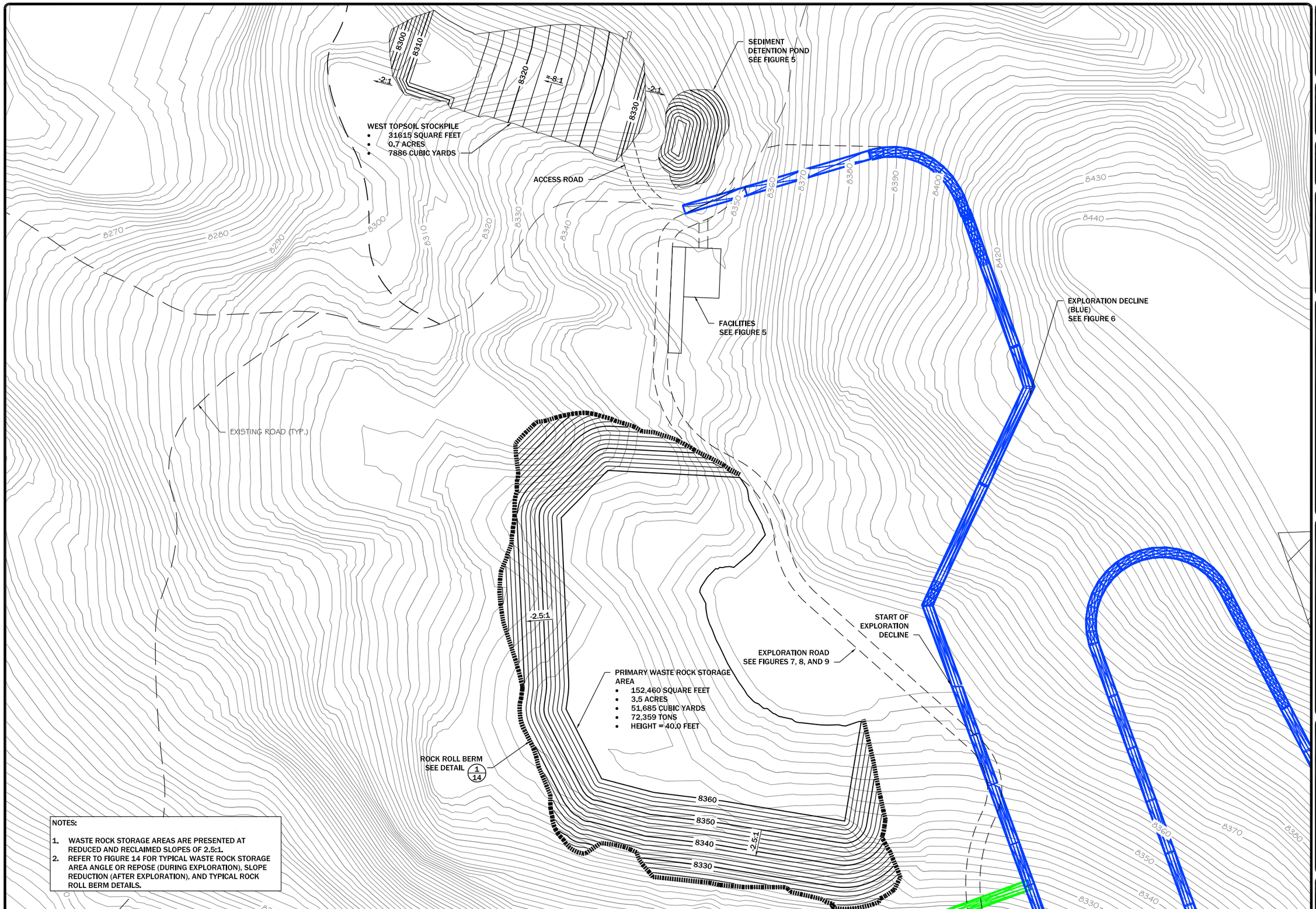

NOTES:

1. WASTE ROCK STORAGE AREAS ARE PRESENTED AT REDUCED AND RECLAIMED SLOPES OF 2.5:1.
2. REFER TO FIGURE 14 FOR TYPICAL WASTE ROCK STORAGE AREA ANGLE OR REPOSE (DURING EXPLORATION), SLOPE REDUCTION (AFTER EXPLORATION), AND TYPICAL ROCK ROLL BERM DETAILS.

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PRIMARY WASTE ROCK STORAGE AREA

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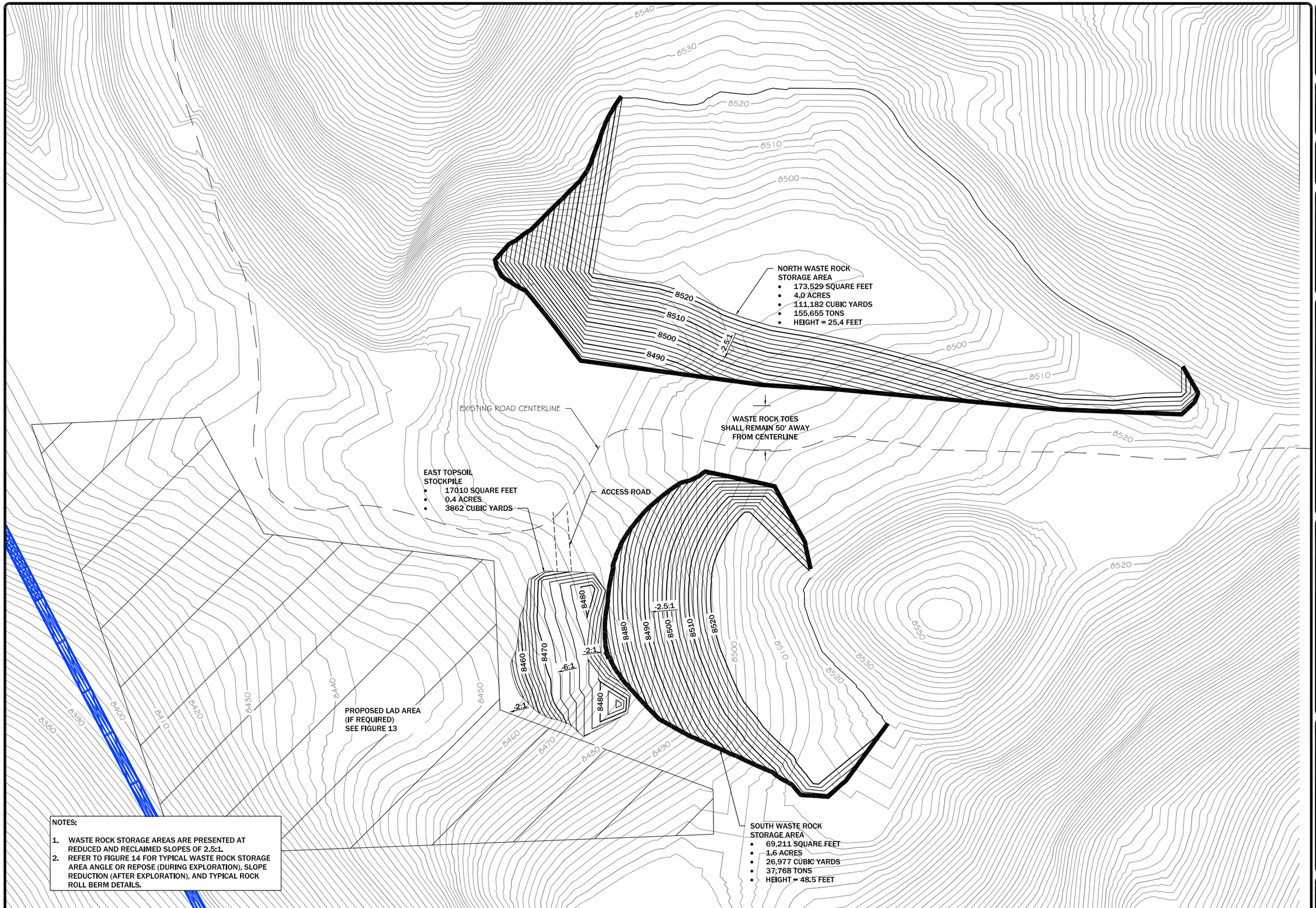
PAGE 16
FIGURE 11



NOTES:

1. WASTE ROCK STORAGE AREAS ARE PRESENTED AT REDUCED AND RECLAIMED SLOPES OF 2.5:1.
2. REFER TO FIGURE 14 FOR TYPICAL WASTE ROCK STORAGE AREA ANGLE OR REPOSE (DURING EXPLORATION), SLOPE REDUCTION (AFTER EXPLORATION), AND TYPICAL ROCK ROLL BERM DETAILS.

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SCALE IN FEET
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EXPLORATION PERMIT

SECONDARY AND CONTINGENT WASTE ROCK STORAGE AREA

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PAGE 17
FIGURE 12

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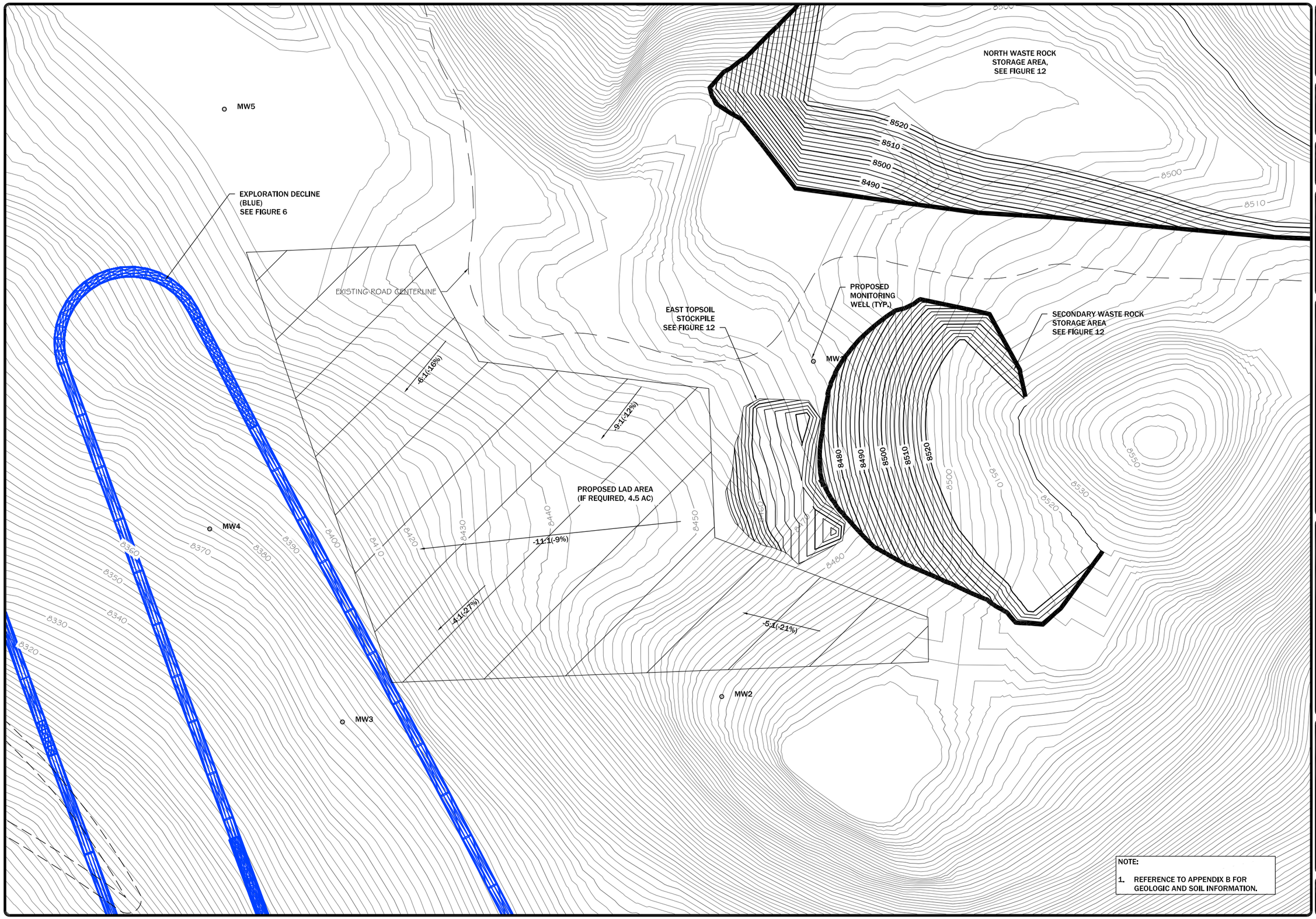

NOTE:

1. REFERENCE TO APPENDIX B FOR GEOLOGIC AND SOIL INFORMATION.

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SOURCE: CMMG LLC

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PROPOSED
LAD AREA

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(406) 457-8252

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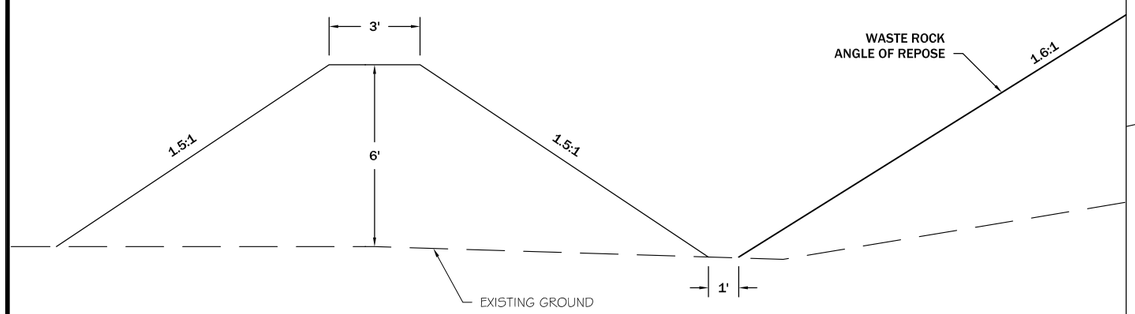
ROCK ROLL BERM TO BE CONSTRUCTED
USING SUBSOIL MATERIALS



ROCK ROLL BERM TYPICAL DETAIL 1

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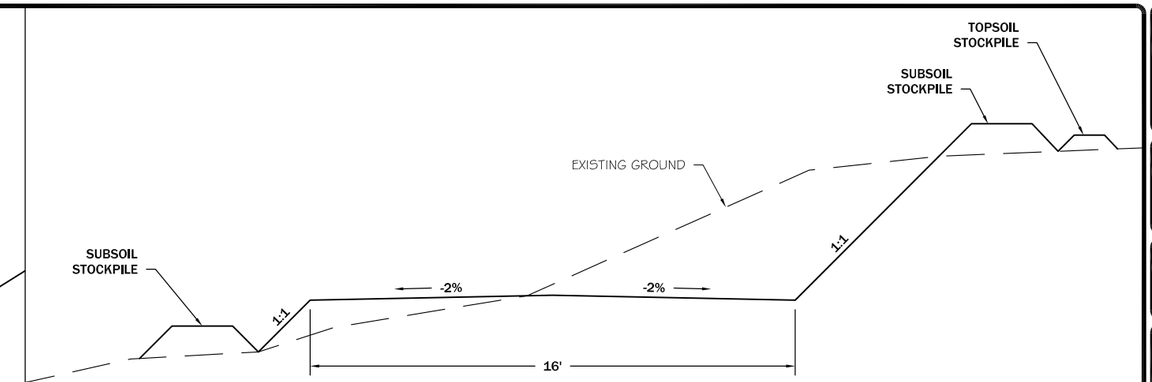

NOTES:

1. TOPSOIL WILL BE STRIPPED FROM THE DISTURBANCE AREA, SELECTIVELY HANDLED, AND STOCKPILED SEPARATELY ON THE UPGRADIENT SIDE OF THE ROAD AS PRACTICABLE DURING CONSTRUCTION.
2. SUBSOILS WILL BE STAGED/STOCKPILED ABOVE AND BELOW THE ROADWAY TO EXPEDITE FILLING THE CUT DURING RECLAMATION.
3. SALVAGED TOPSOIL WILL BE GRADED OVER THE FILL AREA AND RESEEDED DURING RECLAMATION.

EXPLORATION ROAD TYPCAL DETAIL 2

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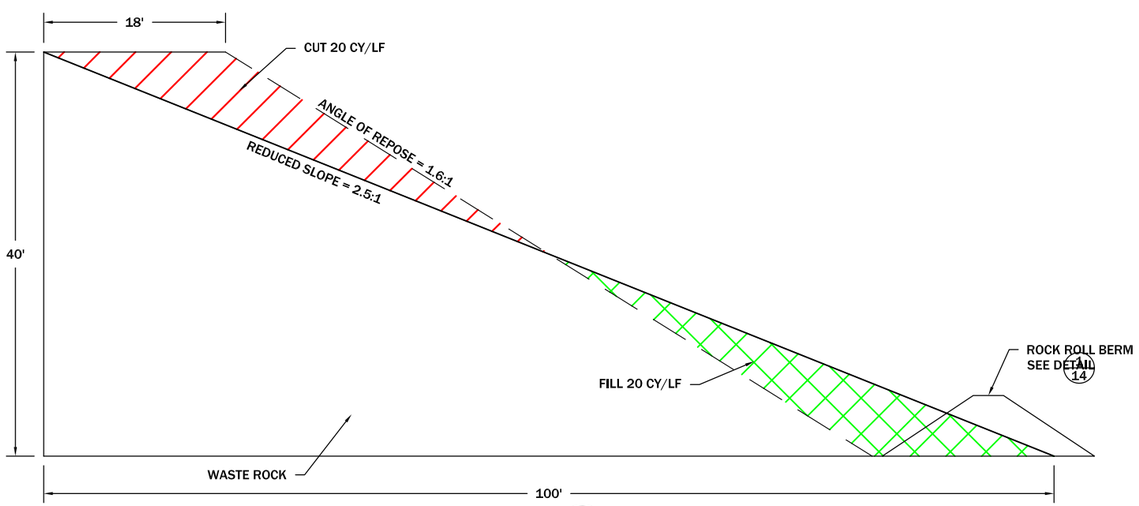

DUMP REDUCTION TYPICAL DETAIL 3

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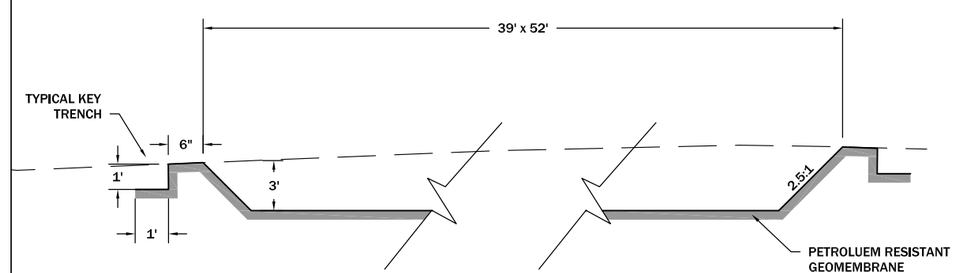

FUEL CONTAINMENT POND TYPICAL DETAIL 4

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SCALE IN FEET
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CREVICE MINING GROUP, LLC
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TYPICAL DETAILS

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6 PUBLIC ROADS

The site will be accessed through a combination of existing Forest Service and Park County roads. In the interest of public safety and to serve project needs, Crevice will complete minor repairs and improvements to the existing road network. Sections of the road where small trees and overgrowth limit line-of-sight visibility will be cleared and corners where visibility is limited will be widened and/or straightened. Crevice will improve the road surface by placing and compacting waste rock generated from exploration operations (if approved after significant analytical testing) on the roadways to create a more durable, weather-resistant surface. No new roads will be constructed for site access, but a section of roadway over private property on patented mining claims is planned for improvement. An exploration road will be constructed within the exploration site limits (see Section 7) and will serve as access for surface drilling. This exploration road will not be a public road.

Road work and maintenance schedules and procedures have been discussed in detail with Park County and the Forest Service. A site-specific road improvement plan will be presented to Park County and the Forest Service for approval. If required, bonding for road reduction after exploration will be levied by the Forest Service. Agreements for post-exploration road configuration will be communicated to Montana DEQ and presented for the record as required under exploration regulations. Coordination will continue during exploration to ensure the Forest Service and Park County agree to the scale and scope of roadway improvements made during development.

Road maintenance and snow removal will be conducted in a manner to preserve and protect roads, to ensure safe and efficient travel, and to prevent excessive erosion damage to roads, streams, and adjacent lands. Where applicable, Crevice will construct turnouts to accommodate public safety. The following specific practices will be employed:

- Maintain drains at switchbacks and otherwise assure that water will drain off the roadbed, minimizing the distance running water will flow down the road.

- Berms will be avoided unless necessary at specific locations for safety or resource protection or as required by the MSHA. Berms remaining from construction activities will be bladed back onto the road surface.

- Cut and fill slopes, if necessary, will be limited to a maximum slope of 1.5 (horizontal) to 1 (vertical) when practical. Cut and fill slopes will be re-vegetated, as practical, at the earliest opportunity.

- Stream crossings will be maintained to minimize sediment loading of streams. Culverts will be kept open. No stream fords will be used.

- Snow will be removed from the entire road width, including turnouts.

- All material removed from the roads during snow removal, except snow and ice, will be kept away from the stream channels and bladed back onto the road bed when weather permits.

- Snow berms will be avoided, as possible, and drainage gaps left at appropriate spacing where snow berming cannot be avoided to facilitate surface drainage and avoid erosion.

- A minimal cover of snow will be maintained on roads to protect roadbeds and minimize erosion.

7 EXPLORATION ROADS

Crevice will construct a primary exploration road to access the project area. The exploration road (see **Figure 7** through **Figure 10**) will traverse patented mining claims and will be fully bonded for reclamation per Montana DEQ regulations. The road will be constructed such that excavated (cut) materials (including topsoil) are staged upslope from the roadway to aid in regrading during reclamation. All BMPs for roadway construction and maintenance (listed previously) for public roadways will be implemented. Drainage culverts will be installed where required.

8 SERVICES

8.1 Power

A portable diesel generator will be installed to supply power. The mining contractor will supply the generator, which will be large enough to accommodate all mining activities plus 75 horsepower (hp) for a diamond-drill unit. The generator unit and an air compressor unit will be enclosed in industry standard enclosures to minimize noise. Crevice will use low sulfur diesel. Crevice will secure the appropriate air quality permits associated with emissions from the diesel generators.

8.2 Water

Potable water requirements are estimated to be in the range of 50 gallons per day. Potable water will be supplied by a commercial bottled water supplier.

Very little groundwater is expected to be encountered during exploration operations. **Table 1** presents historic data confirming that no water was encountered during previous mining and/or exploration operations within the project area. In 1944, George Seager wrote an article on the Crevasse Mountain Mining District in which he recorded that the First Chance was driven in 365 feet, from which a raise was driven to the surface. The adit was then driven another 350 feet for a total of 795 feet. As of the writing, no water was encountered in the First Chance or Highland Chief adits. Present observations indicated that there is still no water associated with the First Chance or Highland Chief. The Vindicator adit, which is lower than the First Chance and on the Gardiner side of the drainage, was driven in 415 feet and no water was encountered. Crevice personnel have observed no water in the historic working described. Crevice management toured

Montana DEQ personnel though the entire project area and surrounding areas to demonstrate no evidence of water in the historical workings.

During exploration associated with the Crevice Tunnel Project, significant water was encountered at the Palmer fault intersection. Crevice contends that the proposed operation is over 2 miles from the area where groundwater was encountered and at a higher elevation. Little to no groundwater is expected to be encountered during the proposed exploration operation. Section 11.3, Water Quality, presents a discussion of baseline data, acid potential, and monitoring planning.

Table 1. Groundwater Observations

Key Point of Interest	Elevation (feet)	Groundwater Observation
Proposed Crevice Portal/ Exploration Decline	8350	Little to no water expected based on historic data
First Chance Adit	8159	No water encountered or presently observed (795 total feet driven)
Base of Crevice Exploration Decline	8365	Little to no water expected based on historic data
Vindicator Adit	7999	No water encountered or presently observed (415 total feet driven)
Highland Chief Adit	7837	No water encountered or presently observed
Crevice Tunnel Project	7500	Water encountered along Palmer fault, which is 650 feet below base of planned decline and over 2 miles away from planned Crevice exploration area.

The exploration portal location is 104 degrees and approximately 1,400 feet northwest of the First Chance Portal. The approximate elevation of the planned Crevice portal is 8,350 feet and the portal of the First Chance Adit is approximately 8,159 feet. The First Chance adit was driven in a nearly intersecting direction to that of the planned exploration adit. Crevice contends that because no water is coming from existing adits on the mountain, a decline driven down dip will not produce water that will be discharged naturally into the environment. The logical assumption is that if the decline development encounters a significant volume of water, development will stop and the management steps outlined in Section 11 will be implemented.

Mine water requirements for drilling and other uses are expected to be approximately 5 gallons per minute (gpm). The water supply will originate from existing surface water rights held within the project limits by Crevice and any water encountered in the exploration drift (expected to be 0-5 gpm). Water will be stored in constructed sumps or, if necessary, stored in tanks located on the portal pad. In both cases, the water will be recycled by a closed-circuit system of surface holding/settling tanks and underground sumps.

8.3 Sewage

Two portable toilets will be located on the site, one at the portal and one at the contractor's service building. Toilets will be pumped regularly by a commercial septic pumping service. The change room ("dry") will be located on the site near the contractor's service building.

8.4 Garbage and Solid Waste

Domestic garbage from the site will be bagged and stored in latching, bear-proof steel containers. Garbage will be hauled to a county pick-up point in Gardiner once or twice weekly or as necessary. Solid waste, e.g., lumber and steel scrap, will be segregated for recycling, where practical, or disposed of in accordance with applicable regulations.

8.5 Housing

Project personnel will be housed in Southern Park County as dictated by the local housing market.

8.6 Fuel and Lubricants

Diesel fuel, oils, and lubricants for surface and underground mobile equipment will be supplied by a local fuel supplier. Aboveground tanks, suited to contain 26,700 gallons, will be located at the portal. The tanks will be set within a bermed and lined sump capable of holding 44,800 gallons. All lubricants will be stored in the contractor's service building or in lined, aboveground storage areas. Used oil will be held in barrels in a lined containment area for pick-up by a licensed used-oil recycler.

8.7 Emergency Services

Emergency services, including fire-fighting, medical, and mine rescue, will be the responsibility of both Crevice Mining Group and its respective contractors. Mine rescue will be provided by Central Mine Rescue located in Osburn, ID. Emergency services will be provided by local providers in Gardiner, Mammoth, and Livingston, MT.

9 Surface Disturbance

The site proposed for the primary waste rock storage area and topsoil stockpile is located 600 feet southwest of the portal and is generally gently sloping terrain. This area holds less timber than the surrounding landscape and will require limited clearing and grubbing. The secondary waste rock storage area is located 1,500 feet southeast of the portal and will be accessed via the existing road from the portal that bypasses the historic Snowshoe site then loops to the north and back to the south and east to the waste rock storage area. This area also holds less timber than the surrounding landscape and will require limited clearing and grubbing. The north waste rock storage area (north of the secondary waste rock storage area) will be accessed by the same road as the secondary waste rock storage area. Total area of surface disturbance associated with waste rock storage areas will be approximately 9.1 acres (**Figure 11 and Figure 12**). Topsoil will be

salvaged, stockpiled, and seeded as soon as practical. Disturbance acreage associated with topsoil stockpiles will be approximately 1.1 acres.

Crevice will construct a surface drainage sediment collection pond downslope of the facilities and portal. The sediment collection pond will encompass approximately 0.17 acres of surface area and will have the capacity to contain 200,500 gallons. Collection ditches will be constructed to route runoff from disturbed areas to the sediment collection pond and diversions will be constructed upslope of disturbed areas to divert runoff waters. Given the nature of the porous soils in the area, excess sediment from runoff is not expected, but Crevice will commit to controlling sediment and will install appropriate BMPs (straw wattles, filter fence, check dams, etc.) in key areas showing potential to produce erosion and sediment runoff. The pond will also serve to store water for dust control and explorations activities (drilling). Crevice will partially fill the pond by way of an existing surface water right on Crevice property or drill a well if necessary. Surface water rights are expected to be adequate to handle water make-up requirements.

Temporary facilities to be located near the portal (**Figure 5**) will include the following:

- Office Trailer (30 feet X 60 feet).
- Shop (40 feet X 56 feet).
- Two Generators (4 feet X 12 feet each).
- Two Compressors (4 feet X 7.5 feet each).
- Two Propane Tanks (4 feet X 16 feet each).
- Water Storage Tank(s) with capacity of 8,000 to 10,000 gallons.
- Electric Switch Gear Box (8 feet X40 feet).
- Parking Lot (15 feet X 120 feet).
- Lined Petroleum Products Containment Facility, which will contain the following tanks:
  - 2 Red Diesel Tanks with capacity of 12,000 gallons each.
  - 1 Highway Diesel Tank with a capacity of 1,000 gallons.
  - Waste Oil Storage Tank with a capacity of 600 gallons.
  - Engine Oil Storage Tank with a capacity of 600 gallons.
  - Hydraulic Oil Storage Tank with a capacity of 600 gallons.

The lined, petroleum products containment facility will have capacity for all fuel/petroleum volume (plus 50% surplus capacity).

10 Development Rock Handling

To provide access for exploration drilling operations, approximately 332,600 tons of waste rock will be produced during development of the portal and exploration decline. The waste rock dumps will be reclaimed when capacity is reached. Stopes will be backfilled when practicable to limit waste rock volume at the surface. After exploration is initiated, waste rock taken from outside the limits of the mineralized zone will be used as road material to improve the access

road network leading to the exploration area. TVX-Mineral Hill used the practice of placing waste rock on roadways to improve road surfaces, limiting the overall need for waste rock storage area and associated disturbance. Waste rock typical of the Crevice Mountain exploration area, after blasting, is well graded, fragmented, and suitable for use as road mix.

To attain Montana DEQ, Forest Service, and Park County approval for road mix, Crevice will commit to completing significant analytical testing for acid generation to prove that the material is inert and will not cause any impact to the environment. After approval, Crevice will place and grade the waste rock material over roadways as approved by the Forest Service and Park County and work the material into the roadway with a grader and vibratory compaction. Waste rock will be identical to rock encountered during TVX-Mineral Hill operations shown in the following photos. Note that the waste rock stockpiles shown in the photos are during active operations. Also note that waste rock stockpiles are nutrient poor and generally lack the physical and chemical characteristics for revegetation success. Crevice will salvage and stockpile all available topsoil as described herein and indicated on the figures to ensure that revegetation success and proper reclamation methods are implemented and achieved.

Photo 1. Waste Rock Stockpile Typical for Crevice Mountain Material

Photo 2. Waste Rock used to Improve Road Surfaces

The planned waste rock storage areas are presented in **Figure 11** and **Figure 12**. Prior to placing waste rock, the planned disturbance area will be grubbed of existing timber, and topsoil will be stripped and stockpiled on the site. Topsoil stockpiles will be shaped to control runoff, seeded, and protected from run-on and runoff by ditches, berms, and BMPs such as straw wattles. The waste rock will be placed and graded in approximate 20-foot lifts and reduced to a 2.5H:1V (horizontal:vertical) slope to limit rilling and erosion. For each respective lift, the reduced slope will be reclaimed prior to placing additional waste rock. Slope reclamation will be completed by placing and grading a 12- to 16-inch lift of topsoil (as available) over the reduced slope; shaping the slope with additional erosion control features (dozer basins, excavator pits, and dozer tracking) to contain runoff; and seeding, fertilizing, and hydromulching the slopes.

Because this is an exploration project, Crevice does not intend to haul the allowable 10,000-ton bulk ore sample off the site.

10.1 Exploration and Definition Drilling

Crevice will complete approximately 64,000 feet (128 drill holes at 500 feet each) of detailed underground diamond drilling by way of drilling from the surface along the exploration road alignment and underground along the decline alignment. The plan includes 36,000 feet of exploration drilling in the first year. Assumptions for the drilling program include the following:

- $ 35 per foot for diamond drilling.
- $ 20 per foot for reverse circulation (RC) drilling.
- $ 20 per sample (sampling every meter for RC drilling and every foot for diamond drilling).
- 100 feet per shift of drilling for diamond drilling.
- One shift per hole for position change.
- 100-foot centers for exploration down dip.
- 50-foot centers for definition drilling.
- Initial exploration will focus on the first 225 feet down dip. Future exploration may expand on this area after initial exploration better defines data gaps.

Year one exploration drilling will include approximately 14,000 feet of primary exploration drilling on 100-foot centers, and 22,200 feet of secondary definition drilling on 50-foot centers. The planned drilling approach includes the following variables:

- Strike length of mineralized zone is 3,800 feet.
- Exploration drill holes will include 178 holes drilled on 100-foot centers at an average depth of 78 feet per hole for a total of 13,728 feet.
- Definition drill holes will include 74 sections drilled on 50-foot centers at 4 holes per section for a total of 296 definition holes and 300 feet total per section for a total of 22,200 feet.

Year two exploration and definition drilling includes a budget for an additional 28,000 feet of drilling, which will be defined based on the sample results of the year one drilling and exploration.

11 WATER MANAGEMENT

11.1 Underground Water

The Crevice Mountain area is a recharge area characterized by ephemeral, seasonal surface, and near-surface flows and very little groundwater flow within the bedrock. Several lines of evidence strongly suggest that very little water is likely to be encountered by underground development (DEQ, 1996):

- Historic records indicating previous mining operations in the district were plagued by chronic water shortages. Miles of old surface ditches in the area provide evidence of the lengths to which miners went to transport water from any available source.

- Past and present landowners in the area have encountered considerable difficulty locating and maintaining permanent water sources for domestic use.

- During periodic inspections completed by TVX-Mineral Hill of a nearby exploration drift over the course of a year, water in-flow was seasonal (spring rain and snowmelt periods) and appeared to be coming almost exclusively from two existing historic raises (i.e., from the surface).

- Previous surface exploration core drilling in the surrounding area encountered significant groundwater flow in only 1 of 50 holes, and that hole was outside of the exploration development area proposed in this plan.

The exact locations of all the core drilling holes from previous explorations are unknown, but are assumed to be in the general location of the current project based on descriptions provided in the 1996 report.

Huntingdon Chen-Northern, Inc. (HCN) completed a water resource baseline investigation in 1993 for the Crevice Mine Project and it is presented in *Water Resources Baseline Investigation for the Crevice Mine Project, Park County* (HCN, 1994). Eleven exploration boreholes were placed in bedrock material and used for measuring static groundwater levels. Short-term aquifer tests in two of the boreholes within the project area were used to evaluate the hydraulic characteristics of the bedrock. The collected values suggested bedrock material of low permeability. Little or no water was encountered during the exploration borehole drilling, confirming the low permeability of the bedrock in this area. The report also noted that because of the fractured nature of the bedrock and low permeability, groundwater elevations measured in the boreholes were variable and a majority of the boreholes had groundwater levels in excess of 100 feet below ground surface.

The Montana Ground Water Information Center (GWIC), an on-line well mapper maintained by the Montana Bureau of Mines and Geology, was searched for the locations of water wells and boreholes in the Crevice project area (http://data.mbmg.mtech.edu/mapper/mapper). Two domestic wells were identified within the immediate project vicinity, and **Appendix B-1 includes** the well logs. Elevations relative to the base of the planned exploration decline are presented below:

1. The Laubach Well located to the northeast:
   a. Approximate well elevation at ground surface = 8,721 feet.
   b. Total depth = 165 feet deep (base elevation of 8,556 feet as compared to the base elevation of 8,150 feet for the proposed exploration decline).
   c. Static water level = 83 feet.
   d. Discharge rate = 1 gpm.

2. The Johnson Well to the northwest (at an elevation more than 1,300 vertical feet lower than the project area):
   a. Approximate surface elevation = 7,029 feet.
   b. Total depth = 195 feet (base elevation of 6,834 feet elevation as compared to the base elevation of 8,150 feet for the proposed exploration decline; or 1,316 vertical feet lower than the proposed base of the exploration decline).
   c. Static water level = 65 feet.
   d. Discharge rate = 20 gpm.

Groundwater flow in the underground development is anticipated to be in the range of 0-5 gpm (DEQ, 1996). Because development water demand is expected in the range of 4-5 gpm, it is likely that the underground water balance will be neutral or negative, resulting in no flow out of the existing portal. To provide makeup water at startup for the operation, Crevice will use existing surface water rights and all groundwater encountered.

Groundwater encountered in the course of underground development will be managed as follows:

- Store all mine water in underground sumps. The size, number, and location of sumps will depend on groundwater flow rate and current mine cycle.
- Recycle as much mine water as possible.
- Construct surface contingency capacity for excess water, if encountered: water storage tanks at the portal, and an approximately 200,500-gallon sediment collection pond downslope from the portal.
- Grout underground inflows as required.
- Drill probe holes in advance of and in conjunction with exploration decline development to determine if groundwater is present.
- Install hole packers and valves or grout diamond-drill holes, which generate excess water.

- Provide make-up water, if necessary, from existing surface sources via an existing water right held by Crevice, including the sediment collection pond.
- Truck water from private sources if necessary.

Excessive groundwater flows are not expected. Probe holes will be drilled in conjunction with decline development and exploration. If excess flows are encountered that will exceed the consumptive use and the capacity of the water storage tanks, the probe holes will be sealed and abandoned as required under the exploration permit requirements and exploration will cease. If manageable flows are encountered and if approved by Montana DEQ, the excess water will be pumped from underground sumps to the proposed LAD/disposal site.

11.2 Surface Water

Surface (runoff) water will be managed as follows:

- Construct diversion ditches and berms above and collector ditches below the disturbed area.
- Construct a sediment collection pond below the disturbed area to which collection ditches will gravity feed; pond capacity will be conservatively designed for the 25-year, 24-hour event (approximately 200,500 gallons).
- Provide an oil skimmer in the event mine water must be temporally decanted into the sediment collection pond.
- Monitor water quality regularly underground and as necessary in the surface sediment collection pond.
- If high groundwater flows are encountered due to periodic surface water inflows, the excess water will be pumped from underground sumps to the proposed LAD site.

11.3 Water Quality

11.3.1 Baseline Water Quality Sampling

Water quality sampling was conducted between 1992 and 1995 in the Upper Crevice area at sample sites including streams, springs, a pond (Frog Pond), a portal (Exploration), adits, and groundwater wells and boreholes by TVX-Mineral Hill and HCN. A grab sample for surface water (spring runoff) was collected in 2015 near the proposed portal area. **Appendix B-2** includes the sample results, which show no elevated metals of concern.

In general, concentrations of the metals in the sampled surface water were low or below detection levels and met Montana DEQ-7 water quality standards (DEQ, 2012). Arsenic levels exceeded the DEQ-7 standard of 0.01 milligrams per Liter (mg/L) in samples collected at the Frog Pond (0.024 to 0.072 mg/L). The Frog Pond is downgradient of the pond at PCT-300, a Palmer Creek tributary (0.028 to 0.046 mg/L), and upgradient of the pond at PCT-100 (0.152 mg/L) and at BCT-300 (0.352 mg/L), a tributary to Bear Creek. Concentrations of iron and manganese exceeded secondary drinking water standards at several sample sites. The sample collected at BCT-300 also exceeded standards for chromium and nickel, but was collected during

early summer runoff and high turbidity. All the sampling sites are likely affected by historic mine working in the area and natural mineralization.

Water samples collected from the Exploration portal and drift (CRA-2) had arsenic concentrations ranging from 0.18 to 1.22 mg/L and elevated levels of iron over the two-year sampling period. Water quality from the other two adit seeps, the exploration borehole, and the two domestic wells was generally good, with a couple of slight arsenic and iron exceedances.

Sampling results show water in the Crevice area to be generally good quality, calcium-bicarbonate type, with the following characteristics (DEQ, 1996):

- Hardness less than 125 mg/L.
- Total dissolved solids less than 155 mg/L.
- Specific conductance less than 210 micromhos per centimeter (µmhos/cm).
- pH 6-8.
- Nitrate + nitrate less than 0.30 mg/L (one sample from the Exploration portal was 0.86 mg/L).

The HCN baseline investigation concluded that surface water quality within the project area is generally of high quality, with some elevated levels of arsenic, iron, and manganese (HCN, 1994). Water from seeps, springs, and adit discharges was generally good with some arsenic exceedances, but relatively low flow rates of 10 gpm, and pH was neutral to slightly alkaline. Groundwater varied both in depth and quality, but in general had few water quality standard exceedances.

11.3.2 Acid Mine Drainage

Despite over 100 years of mining in the district, including historic mines at Mineral Hill and Crevice Mountain, years of operational water quality monitoring have yielded no evidence of acid mine drainage (AMD). Although sulfide-bearing mineralogies have long been exposed to water and air in historic workings, analytical results of water quality sampling at the 1,300-level portal (Mineral Hill Area), driven in about 1910, and at the First Chance Portal (Crevice Area), driven in 1890, show pH values neutral or slightly alkaline, with low sulfide concentrations (Montana Department of State Lands, 1994). These 2 historic mines serve as the best possible predictors of acid-producing potential of mineralized rock in the area.

The HCN report on a 12-month baseline water quality study (HCN, 1994) concluded: "*Analytical results show that water from adits generally is good quality calcium-bicarbonate type with a neutral to slightly alkaline pH (6.0 to 7.7 s.u.). There is no evidence of acid mine drainage from any adits observed in the study area. Concentrations of sulfate (4 to 10 mg/L) are low and the water is soft (14 to 39 mg/L hardness as $CaCO^3$).*"

TVX-Mineral Hill performed acid/base accounting (ABA) analysis on drill-core samples from the Conrad Zone, which represents the rock types to be encountered underground during the Crevice Exploration Project. Static ABA assumes that all sulfur in the samples will be converted to sulfuric acid. Results for Crevice samples indicated the potential for acid generation in 19 of

21 samples (HCN, 1994). Current literature suggests that ABA testing is limited by the assumption that all acidity originates exclusively from pyrite, ignoring other sulfide minerals. As discussed in *A Critical Review of Static Geochemical Test Methods Applied to Mining Wastes, Including Their Applicability to Field Conditions*, presented at the 2012 International Mine Water Association Conference (Rousseau, 2012), *"…other minerals can have a bearing on the result but are often ignored as the assumption that pyrite, if present, is considered to be conservative (analysis) from an environmental point of view. From an economic point of view, however, if other minerals make up a significant proportion of a sample, it may be erroneously classified as potentially acid forming*." Appendix B-3 includes an abstract of Rousseau's report.

On-site evidence at Mineral Hill Mine and at Crevice contradicts results of the ABA analyses and supports erroneous classification. Mineralogy is similar in both deposits: sulfide content of ore averages 6-10% and 5%, respectively, and only a small percentage (approximately 5%) of total sulfides in each deposit is comprised of reactive species such as pyrite (Montana Department of State Lands, 1994). Reported observations of waste rock dumps at Crevice and Mineral Hill show no iron deposition or other evidence of AMD, and historic dumps and old workings support substantial volunteer regrowth of native plants. The measured pH values of Crevice ABA samples run neutral or slightly alkaline, with only 2 of 21 samples below 7, at 6.5 and 6.9, respectively. In addition, water quality samples collected from historic portals at Crevice (Exploration in 1890) and Mineral Hill (1,300 level in 1910) had pH values near or above neutral.

Since there are no field indications of acid mine drainage at either Mineral Hill or Crevice, despite mining activities in the area for over 100 years, it is not anticipated that acid drainage will result from the proposed Crevice Exploration Project activities. Water quality sampling during the project will be performed as necessary to confirm water quality standards are met for any dewatering activities, and BMPs will be implemented to prevent any impacts to surface water. If core samples from the proposed exploration indicate a significant change in lithology, Crevice will provide petrographic descriptions and conduct the applicable geochemical analyses as necessary. Crevice will notify Montana DEQ of any changes.

11.3.3 Water Quality Monitoring

While Crevice does not anticipate needed a LAD area (see Section 12), if it is necessary Crevice will develop a monitoring well network at the proposed LAD area to establish baseline water quality (if groundwater is encountered) and to ensure the system, if required, is functioning as designed and meeting water quality requirements. All water encountered that is local to the project area, including water encountered when developing the exploration decline and local surface water and groundwater (if encountered), will be sampled and compared against available baseline water quality. The monitoring program and frequency will be coordinated with Montana DEQ based on water volume and water quality conditions encountered during exploration, and will include coordination to determine the specific analytical parameters required by Montana DEQ.

12 LAND APPLICATION DISCHARGE AREA

Crevice does not anticipate the need for a LAD area. Crevice is more concerned about obtaining sufficient make-up water by way of existing surface water rights and/or groundwater wells (application for beneficial use in process) for exploration and dust control requirements. However, Crevice intends to have a plan in place in the event excess groundwater is encountered. Crevice will complete a full-scale characterization effort for the proposed LAD area. A monitoring well network will be established and include both upgradient and downgradient wells for establishing baseline data. No water is expected to be encountered for the monitoring wells, but the wells will be installed to a minimum depth of 250 feet to confirm this assumption and to serve the purpose of monitoring the site in the event the LAD is required. The proposed LAD area (if required) is shown on **Figure 13**.

Water quality will be analyzed and the LAD, when approved by Montana DEQ, will be operated at agronomic rates during the growing season only (no groundwater discharge authorization required, but seasonal discharge only, and not during rainy periods).

While not expected, if excessive water volume is encountered, the LAD will be designed to accommodate discharge to subsurface but managed such that there is no potential for surface runoff of irrigated water. Irrigation would be limited to within the growing season and, depending on volume and water quality, Crevice will meet the following Montana DEQ requirements:

- Irrigated water would meet all groundwater quality standards before irrigation (except possibly nutrients [nitrate] that would be consumed by vegetation during the growing season). However, treatment may be required for arsenic or other constituents that may be present in the water above standards); or

- Montanan DEQ would require hydrologic tests, soil attenuation tests, monitoring, and a mixing zone determination to document that all constituents of concern would be adsorbed to soils and/or diluted by mixing with ambient groundwater beneath the LAD area to the degree that there would be no exceedance of any standard at the downgradient edge of the mixing zone. Groundwater monitoring requirements would be site-specific and dependent upon topography, etc., of the LAD area, but as a general rule DEQ would require at least one upgradient well and three downgradient wells.

If water disposal cannot be limited to summer months, a subsurface disposal system (drainfield) may be considered. In this case, no allowance for nutrient uptake during summer months would be made, and water quality standards for nutrients would be met year-round. An Underground Injection Control (UIC) permit from the U.S. Environmental Protection Agency (EPA) may also be required. All other conditions for the LAD mentioned above would still be required (compliance with standards either at the point of discharge or at the end of a mixing zone). The EPA generally requires compliance with groundwater standards at the point of discharge under a UIC permit.

The proposed LAD area is adjacent to the secondary waste rock storage area. The proposed LAD area is presented in **Figure 13**. Natural Resource Conservation Service (NRCS) soils data for the proposed LAD area indicate favorable Hydrologic Group B soil conditions for water absorption, which are conducive to a well-functioning LAD system. **Appendix C** includes a custom NRCS soils report of the proposed LAD area. The proposed area falls within Map Unit 34-1B.

13 Site Reclamation

The facilities and infrastructure layout at the exploration portal are designed to minimize impacts. Hence, complete site restoration can be readily achieved. When exploration is complete, and if exploration results are favorable for long-term mining, infrastructure related to exploration will be reclaimed and the portal and decline will be used for future mining purposes. The portal area will be managed as follows:

- Remove all temporary structures.
- Re-establish, as nearly as possible, pre-project topography.
- Properly abandon drill-holes per Administrative Rules of Montana (ARM) 17.24.106.
- Replace topsoil and revegetate disturbed areas.
- Regrade and re-establish pre-exploration drainage conditions.

If exploration results are not favorable, Crevice will complete all the actions above in addition to sealing the portal [per ARM 17.24.107 (6) requirements], decline, and raise(s) to prevent access and inflow/outflow of water.

13.1 Bonding Requirements and Calculations

Crevice will fully bond for all disturbance associated with exploration, including waste rock storage areas, exploration roads and ancillary areas, storm water BMPs, required dust control, weed control, and contingency for all secondary disturbance such as debris and additional erosion control measures.

Montana DEQ will calculate the actual bond requirement based on the information provided herein. **Table 2** (on page 35) lists estimated bond requirements calculated using recent construction/reclamation costs on comparable reclamation projects. An itemized description of the bond calculations is below:

- **Mobilization, Bonding, and Insurance:** For contracted work and construction bids, costs associated with mobilization are generally calculated at 10 percent (10%) of the total construction costs. This bond item covers bonding and insurance costs for prospective contractors. It is considered a conservative estimate given the proximity of the site to contracting entities.

- **Waste Rock Storage Areas**: When the primary waste rock storage area reaches capacity, Crevice plans to reclaim the area while the secondary waste rock storage area is under

development (See **Figure 11** and **Figure 12**). However, Crevice will bond the full 9.1 acres of disturbance associated with primary, secondary and north waste rock storage areas. Included in the bond calculation are costs for regrading and reducing the waste rock slopes; excavating, loading, placing, and spreading cover soil; fertilizing and seeding; hydromulching; and constructing run-on and runoff control drainage. Also included are costs for reclaiming the disturbance associated with topsoil stockpiles areas.

- **Exploration Roads and Ancillary Items**: Crevice will construct the exploration road such that spoils and topsoil are stockpiled upgradient from the roadway to provide efficient operations during road grading and reclamation. Drill pads scheduled for surface drilling that are constructed along the exploration road alignment will be reclaimed concurrently as exploration operations advance. Montana DEQ will determine the bond based on the information provided herein.

- **Dust Control**: Crevice will bond for required dust control associated with reclaiming roadways, waste rock storage areas, and ancillary areas related to the exploration work. It is estimated that reclamation for the total disturbance acreage will take a competent contractor approximately 1 month. For the purpose of dust control and the limited acres, 60 loads from a 4,000-gallon water truck are considered sufficient for dust control measures, should bonded work be required.

- **Storm Water BMPs**: This item includes all potential erosion control measures that may be required to ensure the site is stable. The items include typical engineering tools that are commonly implemented on construction projects, including filter fence, straw wattles, erosion control mat, stone check dams, riprap, and geotextiles placed prior to placing riprap.

- **Weed Control**: Although the disturbance area is limited to approximately 14 acres, Crevice will bond for weed control on 17 acres for 3 years. The bond estimate equates to $100.00 per acre for 3 years and is considered sufficient for commercially available weed control contractors.

- **Landfill Debris Disposal**: Crevice commits to keeping the site clean and will control debris and litter as outlined in Section 14.2, Solid Waste. However, Crevice will bond for landfill debris disposal if required to properly reclaim the site.

- **Ten Percent Contingency**: The total estimated bonded value of $181,010.90 equates to nearly $12,978.00 per acre of disturbance associated with the exploration plan (14.0 acres), Crevice proposes an additional 10% bond in the amount of $16,985.90 to account for unforeseen reclamation costs. The total bond value will be $203,830.80.

Crevice will not post bond for the contingent LAD area (**Figure 12** and **Figure 13**) unless the areas are actually used.

Table 2. Exploration Bond Calculations

Crevice Mining Group LLC Exploration Bond Estimate					
BOND ITEM	**DISTURBANCE/ RECLAMATION QUANTITY**	**UNITS**	**DESCRIPTION**	**UNIT PRICE, $**	**TOTAL PRICE, $**
1	1	LS	**MOBILIZATION, BONDING, AND INSURANCE**	LS	$16,985.90
Lump sum for Mobilization, Bonding, and Insurance Caluclated at 10% of Bonded Items					
2			**WASTE ROCK STORAGE AREAS**		
2a	10	Acres	Regrade and Reduce Slopes	$1,200.00	$12,000.00
2b	11,700	CY	Excavate, Load, Haul and Place Coversoil	$3.50	$40,950.00
2c	10	ACRES	Fertilize and Seed	$1,100.00	$11,000.00
2d	10	ACRES	Hydromulch	$850.00	$8,500.00
2e	2,000	LF	Construct Run-on and Runoff Control Ditches/Drainage	$6.00	$12,000.00
3			**REMOVE AND RECLAIM EXPLORATION ROADS & ANCILLARY ITEMS**		
3a	3,000	LF	Reclaim Exploration Road	$9.00	$27,000.00
3b	10	EA	Reclaim Exploration Drillpads	$500.00	$5,000.00
3c	10	EA	Drillhole Abandonment	$800.00	$8,000.00
3d	6	EA	Remove 18" HDPE Culverts	$300.00	$1,800.00
3e	1	LS	Remove and Reclaim Facility Area	$6,000.00	$6,000.00
4	0	ACRES	**RECLAIM LAND APPLICATION DISCHARGE AREA**	$2,000.00	$0.00
5			**PROVIDE WATER FOR DUST CONTROL**		
5a	1	LS	Water Loading Area	$800.00	$800.00
5b	60	Loads	Provide 4000 Gallon Water Trucks	$100.00	$6,000.00
6			**STORM WATER BMPs**		
6a	500	LF	Filter Fence	$5.75	$2,875.00
6b	1,200	LF	Straw Wattles	$7.50	$9,000.00
6c	1,000	SY	Erosion Control Mat	$3.75	$3,750.00
6d	6	EA	Stone Check Dams	$200.00	$1,200.00
6e	50	SY	Install Type 1 Riprap	$50.00	$2,500.00
6f	50	SY	Install Type 2 Riprap	$75.00	$3,750.00
6g	100	SY	Bank Stabilization Geotextile	$4.00	$400.00
7	19	ACRES	**WEED CONTROL (Three Year Total)**	$300.00	$5,834.00
8	50	CY	**LANDFILL DEBRIS DISPOSAL**	$30.00	$1,500.00
9	1	LS	**10% CONTINGENCY**	$2,000.00	$16,985.90
				SUBTOTAL	**$203,830.80**

AC = Acres EA = Each SY = Square Yards

CY = Cubic Yards LF = Linear Feet LS = Lump Sum

14 Mitigating Measures

14.1 Air Quality

The potential for fugitive emissions during the project exists on the county access road and at the waste dumps, facilities, surface drilling, and surface haulage. Crevice will apply water and/or chemical stabilization to the road and any other disturbed area as necessary to minimize wind erosion emissions. Crevice will coordinate closely with Montana DEQ, the Forest Service, and Park County to ensure dust control measures are satisfactory.

Crevice will secure the appropriate air quality permits, where required, associated with emissions from the diesel generators and all applicable requirements. The exploration area does not fall within a Class I airshed. Generators used will meet the air quality requirements mandated by the Montana DEQ air quality permit (if required). For the diesel generators, IP56 silent enclosures will be used. Crevice will use low-sulfur diesel. Crevice intends to develop and use three-phase grid power as soon as practicable.

14.2 Solid Waste

Solid waste disposal will be in compliance with all applicable federal, state, and local regulations. All garbage, refuse, and waste will be contained in appropriate containers and removed from the site not less than weekly.

14.3 Scenic/Aesthetic Values

The proposed exploration portal site and associated waste rock storage area was selected, in part, to minimize visual impacts. The site is shielded from view by topographic features and trees and is not visible from Yellowstone National Park or from most other vantage points.

New surface disturbance will be limited to a small area. Sheltering trees will be retained, and total tree removal will be limited to the extent possible. Infrastructure developed for lighting needed to work at night, where required, will be directed downward and shielded where practicable.

14.4 Fish and Wildlife

The nearest perennial stream to the Crevice site, Malin Creek (approximately 3,500 feet from the portal), is a first-order tributary of the Yellowstone River, which falls approximately three quarters of a mile short of physically draining into the river and almost certainly does not support a fish population. Storm water runoff from disturbed areas at the project site will be diverted into constructed ditches (as previously described) to eliminate sediment loss from the site to the Malin Creek drainage.

All appropriate measures will be taken to avoid negative impacts to or conflict with wildlife. Traffic speed limits will be strictly enforced and drivers trained to watch for and avoid wildlife on roads. No firearms will be permitted on company property. No pets will be permitted on the

project site. All garbage, food, or other potential bear attractants will be secured from bears at all times. Garbage will be stored in bear-proof, latched containers and removed from the site at least weekly.

Sightings or signs of wildlife will be reported to supervisory personnel and recorded on standard wildlife observation forms.

14.5 Cultural Resources

Historic and prehistoric cultural resources, if encountered, will be preserved in place, if possible, and otherwise preserved and recorded in accordance with state and federal standards.

14.6 Hazardous Substances

Use and storage of hazardous substances are not anticipated and will be avoided. However, any such materials necessary to the successful completion of the project will be handled in accordance with all applicable local, state, and federal standards and BMPs. Safety Data Sheets will be on hand for all materials contained on the site.

14.7 Sediment Control

As previously discussed, off-site sediment losses will be controlled by a system of diversion and collection berms and ditches in conjunction with a sediment collection pond. Temporarily stockpiled topsoil will be seeded immediately to prevent soil erosion. Additional erosion control measures (BMPs) will be installed in critical erosion-prone areas identified in the field, including areas associated with the exploration roads. Crevice will comply with Montana DEQ regulations for Storm Water Pollution Prevention Plans (SWPPP), inspection, and administration.

14.8 Water Management

It is anticipated that little, if any, groundwater will be encountered in underground operations. As previously discussed, mine water will be contained in a closed-circuit system and recycled. Surface tanks may initially be used to hold and settle mine water prior to recycling. If excessive water volume is encountered, the water will be pumped to the LAD site to be permitted at a later date if necessary (see Section 12). Fugitive oils (sheen or film) will be skimmed from tanks and sumps prior to recycling.

If water is encountered in the diamond drill-holes, the holes will be plugged with hole packers and valved or grouted. Water quality will be monitored regularly.

14.9 Fire Prevention and Control

All applicable local, state, and federal fire prevention and burning standards and BMPs will be adhered to. No open fires will be permitted on the project site.

Chainsaws will be equipped with approved spark arrestors. Fire extinguishers will be kept on the site and in good working order at all times, and hand tools, pumps, and heavy equipment will be available for fire control.

14.10 Fuel Storage

Aboveground fuel tanks will be set in a lined, petroleum products facility. There will be no underground or buried fuel tanks. Regular inspections will be made to ensure that tanks and filling hoses and nozzles are in good condition and not leaking.

Oil/fuel absorbing materials will be kept at the exploration office in the event of minor spills or leaks. All applicable local, state, and federal regulations and BMPs with regard to storage, handling, and use of fuels will be followed.

14.11 Noxious Weed Control

To prevent introduction of noxious weed seed, all mobile equipment and vehicles will be thoroughly washed at an off-site location and inspected by a qualified supervisor prior to mobilizing onto the project site. Equipment or vehicles leaving the project site will be washed again and inspected before redeployment on the site. No hay or straw will be permitted on the project unless management has designated a specific need and then only if it is certified weed-free. Crevice will contract weed control services during exploration to control the spread of noxious weeds. In addition, Crevice will fully bond the exploration disturbance areas (and surrounding roadways) for three years/seasons of weed control.

14.12 Transportation

To eliminate the need for road building, existing roads will be used for the duration of the project. Traffic between Jardine and Crevice will be kept to minimum practical levels by coordinating supply trips and by transporting workers in multi-passenger vehicles. Additionally, consumable items such as fuel, water, drill bits, etc. will be stockpiled to the extent possible prior to the opening of the general hunting season in the fall. This practice will minimize the amount of traffic on the existing roads and will minimize potential conflicts between mine operations and hunters.

14.13 Noise

The mine generator and compressor at the portal will be housed in a sound-attenuating temporary structure. Some near-surface blasting will occur during portal construction, but only during the daylight hours. Exploration drilling from the surface will be limited to daylight hours.

14.14 Socioeconomics

Contractors will be encouraged to hire workers from the local labor pool and to purchase goods and services locally as much as possible.

15 PROJECT SCHEDULE

The exploration project has a proposed 18-month schedule planned to start in 2016 and be completed in 2017. The exploration project will be completed in two phases:

Phase 1 (2016)

1. Develop necessary facilities associated with the exploration project.
2. Start the exploration decline.
3. Develop the primary waste rock storage area.
4. Develop an exploration road.
5. Initiate exploration drilling from the surface along the exploration road alignment.
6. Initiate underground exploration drilling along the exploration decline.

Phase 2 (2017)

1. Complete the exploration decline.
2. Develop the south waste rock storage area.
3. Complete secondary surface drilling adjacent to the exploration road and south waste rock storage area.
4. Complete the remainder of the underground drilling program.

Waste rock storage area reclamation and areas disturbed by surface drilling will be reclaimed concurrently as exploration work progresses. The final site restoration will be completed upon review of the project feasibility study associated with exploration results. If exploration and modeling results are favorable, Crevice will consider an application for an operating permit.

16 REFERENCES

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Appendix A : Crevice Mountain Resources and Reserves

Appendix A-1

American Innovative Minerals LLC
Letter Report: Crevice Mountain Compliant Resources and Reserves

3365 Colton Drive, Suite B
Helena, MT 59602

406-475-3614 Office
406-475-3615 Fax

American Innovative Minerals LLC

Michael Werner, President
Crevice Mining LLC
7425 East Columbia Drive
Spokane, WA 99021

June 18, 2015

Dear Mike:

I have had the opportunity to review the Crevice data and site and although a significant amount of historic drilling has been completed the historic resource reserve by TVX is not a modern compliant reserve. Resource standard have dramatically become more rigorous and there are some large gaps in the drilling and data. The numerous intercept are encouraging to indicate that there could be a significant amount of gold in the ground, the historic work is lacking some very critical quality control and geologic data that would allow the deposit to be consider a compliant resource.
At least 15% of the known resources intercepts would need to drill tested, from either an underground or surface platform with proper quality control, geologic definition, metallurgical testing to bring this deposit into resource. A feasibility study would need to be completed to announce different reserves categories.

This is a nice advance exploration property and with additional drilling, especially in the areas where gold has not yet be identified, will likely help to build a good resource. I will work with Andy to put together a plan and estimate of the time and costs to build this into a modern resource.

Sincerely,

Alan Branham
CPG-10979
President & CEO
American Innovative Minerals LLC

File MT-138

Appendix A-2

Geology of the Crevice Mountain Gold Mine, Park County, Montana

By Alan Branham, CPG #10979

5. **Geology of the Crevice Mountain Gold Mine, Park County, Montana**

by Alan Branham, CPG #10979

July 16, 2015

5.1 Historic Production

Mining began in the Crevice Mine area in 1879 with the discovery at the Highland Chief by Neil Gillis and Charles H. Wyman (Seager, 1944). Gillis and Wyman sold their interests in 1891 to Edgerton and Jewell who formed the Crevasse Mining Company. They constructed a 10 stamp mill which was enlarged to a 20 stamp mill. The Crevasse Mining Company was again sold in 1898 to W.D. Conrad and James Stanford of the Conrad-Stanford Bank in Helena. Production resumed in 1904 to 1908 on the Conrad zone and has been idle since that time. Production from 1898 to 1908 totaled $128,363.41(6,763 ounces gold). The mine was shut down due to difficult access and inadequate water supply from Palmer Creek. The steep access road made haulage to the Jardine mill difficult and expensive.

The McClauney was the most productive mine in the Crevice Mountain area. In 1911, eleven sacks of scheelite were mined from the McClauney. During World War II the mine was investigated for tungsten for the war effort but no production occurred.

In 1892 the Park View Mining Company was organized to develop the Tower Grove and Snowshoe Mines, but only the exploration work was completed. In 1931 a Herman type pebble mill was installed and in 1932 approximately 800 tons of 0.21 ounce per ton gold was produced (168 ounces gold). Production occurred in the summers with the establishment of a flotation mill and total production from the Snowshoe from 1934 to 1939 was $25,000 (718 ounce gold).

The Medona mine was worked from 1934 – 1937 by the Montana Vindicator Gold Company which produced 800 tons of ore that recovered 43 ounces of gold (0.054 ounce/ton(opt) and 15 ounces of silver. During World War I $2500 worth of scheelite was produced and sold from the Medona. Low grades inhibited the Medona from further development.

Total production from the Crevice District is estimated at 7,692 ounces of gold with minor byproducts silver and scheelite.

5.2 Exploration History

Initial modern exploration work began in 1974 under a joint venture between American Copper and Nickel and the Homestake Mining Company. Approximately 40 square miles around the Jardine area were explored for “Homestake type,” mineralization. The joint venture secured mineral rights in 21 square miles of this area. From 1974 to 1979 the companies conducted basic reconnaissance exploration which included stream sediment sampling, geologic mapping, soil surveys, rock chip sampling, petrographic work, magnetic surveys, I.P. surveys, and VLF- R surveys. In 1979 a few drill holes tested the Mineral Hill and Crevice Mountain areas. Discoveries were made and the initial focus was development of the Mineral Hill area. The Crevice Mountain area represented the second largest gold anomaly but because of access, better mining development and the better mill site along Bear Creek, the Mineral Hill Mine was developed first.

In 1993, when ore began to run out at Mineral Hill focus expanded to the Crevice area, where in 1980 several drill holes began the exploration of the Conrad zone. The joint venture had been spun off into a subsidiary named TVX. In 1994 additional drilling was conducted on the Conrad and Tower Grove zones, expanding the discovery. An idea to drive an underground drift two miles from Mineral Hill to beneath this new discover and mine the ore without having any surface disturbance visible from Yellowstone Park was approved. In 1996 additional drilling was conducted on the Conrad zone. The drilling focused on the area where the underground tunnel would be developed, so that a mineral resource and reserve could be planned. Surprisingly, much of the deposit from the surface to about 300 to 400 feet down dip along the vein zones were not drilled or sampled, due to focus on the areas near the planned underground tunnel. The tunnel was driven part of the way to the Conrad zone and hit some unexpected high water flow zones. The mine did not have a water discard permit, this, coupled with lower gold prices, caused it to shut the project down in 1997-98.

5.3 Geochemistry

Approximately 4150 surface samples have been collected across the district that are recoverable from the Inco-Homestake joint venture from 1974 to 1979, approximately 40 square miles. The samples are described by Davis (1979) as follows:

Soil samples were (2810) collected on grids approximately 400 feet spaced East-West lines; samples were collected at a 4 to 6 inch depth, screened to 10 mesh in the field and -80 mesh at the lab. Samples were analyzed for gold (+/- 20 ppb), silver (+/- 100 ppb), copper (+/-1ppm), lead, (+/-1ppm), zinc (+/- 5 ppm) and mercury (+/-10ppb). Some infill lines and tighter sampling was conducted in areas of interest.

Rock chips (146) were collected for analysis with a duplicate for thin section and petrographic work. Rocks were analyzed with the same geochemical analysis as the soils. Most of the rock samples were type samples from core but a few were collected at the surface in old pits and mine dumps. Surprisingly sparse surface sampling was conducted in the Conrad zone despite obvious veins at the surface.

Stream sediments (112) were collected as 1 to 3 pound samples of (-30 mesh) screened and pan concentrates on 500 yard or major drainage splits over the entire district. The stream sediments were sampled, dried and sieved in the labs to -80 mesh. Stream sediments were analyzed with the same elements and detection limits as the soil samples.

Vegetation samples (82) were collected from pine, spruce, and juniper twigs, and analyzed. Not much information was noted from the vegetation sampling.

Homestake plotted all the samples without discriminating the type of samples using the same cut-off values for anomalies whether the samples were pan concentrates, rock chips or soils. Better analysis is recommended with this historic data.

Three gold and pathfinder anomalies were discovered outside the Jardine/ Mineral Hill areas:

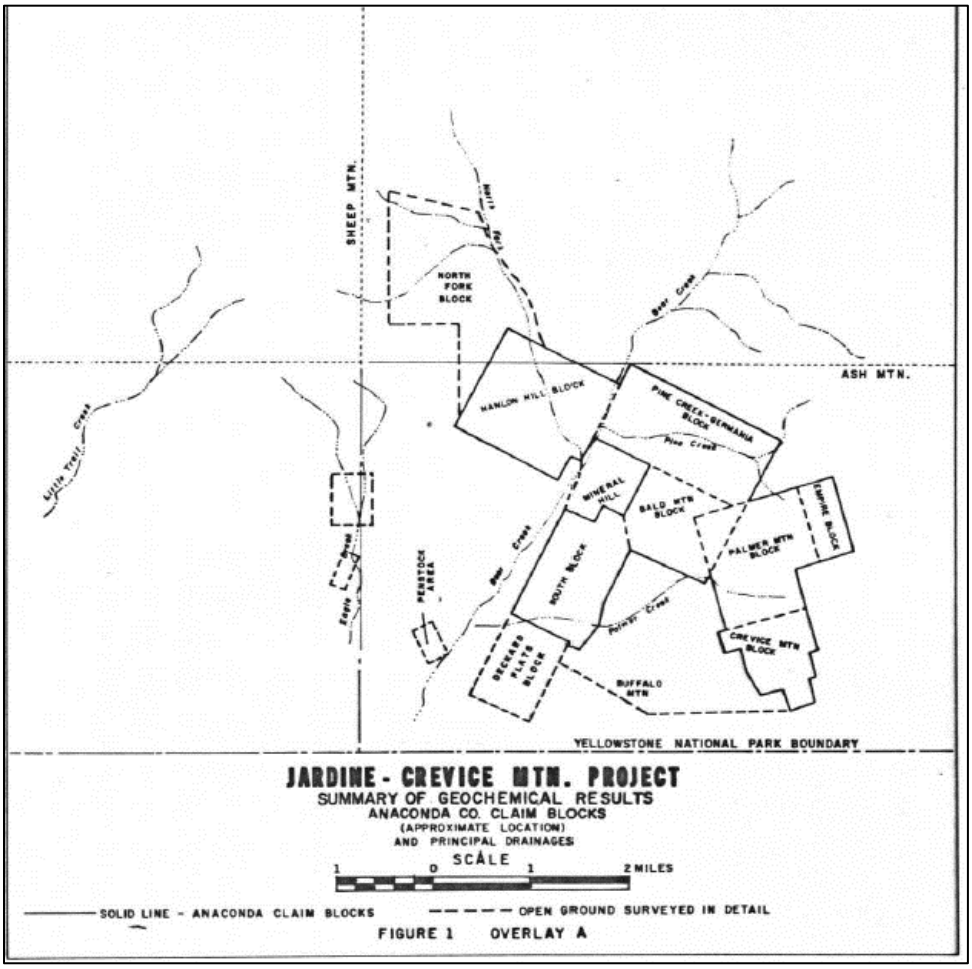
1) The strongest anomaly was the Crevice Mountain/ Conrad zone which was a strong gold anomaly with arsenic, lead, copper, and zinc. The anomaly was approximately 5000 foot long beginning around the historic Conrad Adit, striking N25E with a width of 400 to 5000 feet wide, the widest zone being across Buffalo Mountain area. Gold values over 10,000 ppb outlined the

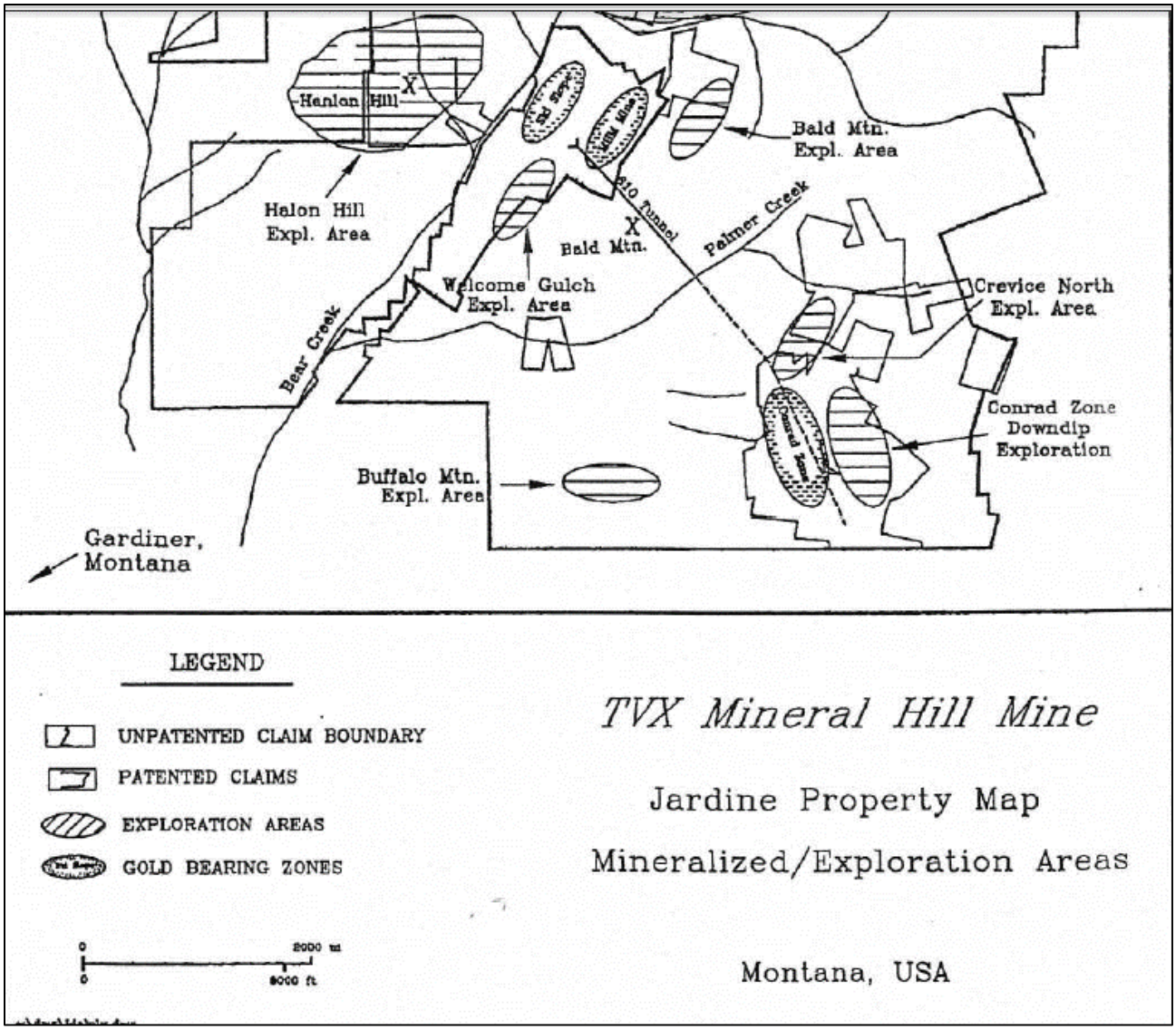
areas where the gold zone comes to the surface as 3 to 10 foot wide quartz veins. Several of the surface soil and rock chip anomalies match well with up dip projections of the vein/ strands discovered in the drilling.

2) The Tower Grove anomaly is the second largest gold anomaly approximately 1500 feet long in a N30W strike again with strong surface gold anomalies up to 0.3 ounces per ton.
3) The NW Flank of Crevice Mountain and west of Jones cabin defined a gold anomaly associated with Banded Iron Formations (BIF) that is said to be 3000 feet long and 1000 feet wide in N54W strike. This anomaly may be cut-off or hidden to the north by post mineral glacier gravel.

The anomalies are well summarized and illustrated by large scale (1:6000) geochemical map scans collected from Kinross data review.

The data is best summarized by Davis, 1977 in his “Geochem Report,” copied from the Kinross data room.





5.4 Geophysical Surveys

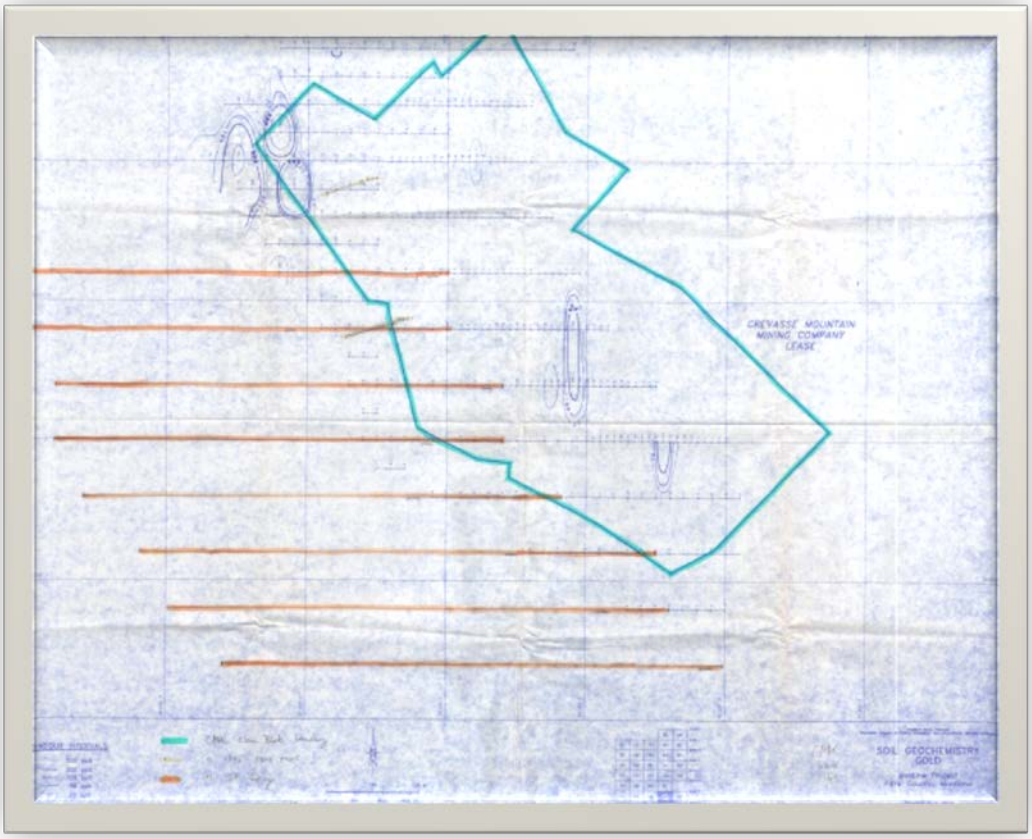
Four types of geophysical surveys were conducted over the Crevice Mountain area; airborne magnetic survey, ground magnetic surveys along soil lines, Induced Polarization (IP) and VLF-R surveys.

The magnetic surveys were useful in mapping Banded Iron Formation (BIF) and iron rich cummingtonite schist zones that are associated with the gold zones. Intrusions were also well mapped. A broad airborne survey was conducted over the entire land package in 1980 and a detailed ground magnetic survey was conducted on 400 foot spaced east- west striking soil lines over the Conrad area. A detailed interpretation of the magnetic surveys was not found in the Kinross data, but the BIF zones surrounding the gabbro intrusion, north of Tower Grove were clearly identified.

Figure 5.4 -1 **Ground magnetic survery lines in the Crevice Mountain area**

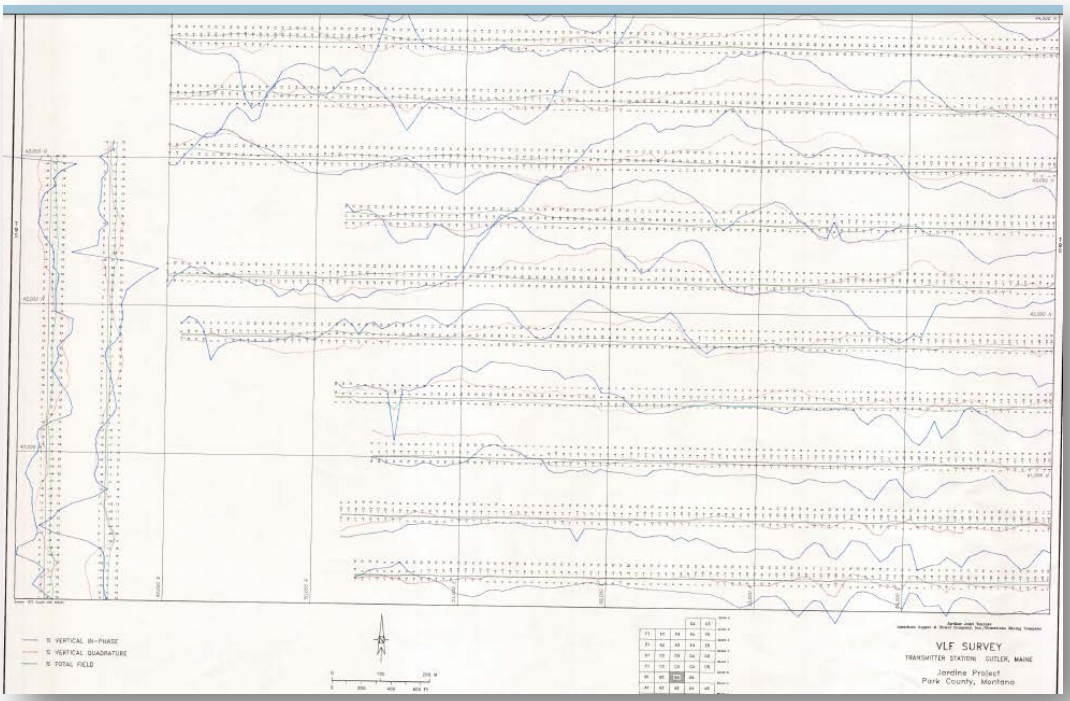
The IP surveys were used in limited areas to help focus drilling in the Jardine/ Mineral Hill areas for sulfide mineralization associated with the high arsenopyrite associated with the gold. Eight IP surveys were conducted in the Crevice Mountain area along the 400 foot spaced soil lines, as shown in Figure 5.4-2 below. Anomalies were identified and tested by drilling.

Figure 5.4-2 IP Survey lines in Crevice Mountain area



The VLF-R surveys were used to help identify faults and mineral zones but were considered of limited use. The surveys were used to help delineate alluvial and gravel thickness and identify faults. Shown below are the soil lines that were used where VLF-R was conducted in the Crevice Mountain area.

Figure 5.4-3 VLF-R survey lines in Crevice Mountain area (1991)



5.5 **Drilling (sampling, logging, quality control, data)**

Drilling was conducted over a several year period and was almost entirely core. The only uncertain holes were the 1973 holes drilled by Anaconda, which are lacking descriptions and logs. However, Anaconda typically used core holes during that period of time in Montana. Assays of the few 1973 holes by Anaconda are included in the database.

All the holes drilled by Inco, Homestake, or TVX used the same protocol. The holes were drilled, a deviation survey was conducted, the collar was surveyed by either brunton and tape to a known mine grid, or later by a surveyor with a transit. The holes were logged by a geologist and sample intervals were collected to as small as 1.5 feet but typically no more than 5 or 6 feet, using geologic boundaries as sample points. Cores were split in half and assayed. The samples were assigned a sample number which was also included on the drill log. Early holes were assayed for gold, copper, silver, and tungsten. Later holes were mainly sampled for gold and occasionally tungsten. Gold was assayed in triplicate from the first sample.

Apparently, a uniform protocol was used in assigning rock type and alteration assemblages, although it may have evolved and expanded as the drilling progressed. Similar log sheets were used that recorded rock type, alteration. In some of the 1981, all the 1994 and 1996 RQD, bedding angle to core axis, and veins or structure angle to core axis were recorded. All this data was put into the Boris database and most of it was recovered in the digital database. Additional angle to core axis of mineralized intervals are recorded on drill logs but are not in the digital database.

In terms of quality control for the gold and silver assays, the project was typical of the exploration groups of the time period. Gold and silver were run as a fire assay, typically at the mine site or with a well-known lab, typically ALS/Chemex Labs in Reno. The assays were noted to be fire assay with an Atomic Absorption finish. The assay size is not noted on the assay sheets but typically was a standard assay ton (34 grams) during that time period, although in the early 1980's a 10 gram fire assay was occasionally used at Chemex . Triplicate fire assay were conducted on the 1994 and 1996 samples and in a few cases screen fire assays of up to 500 to 1000 grams were conducted but no reports were made to summarize the duplicate checks with the screen fire assays. Gold values were averaged from the duplicate and triplicate samples and a separate gold average was reported in the database. Just a visual check showed that in most cases the duplicate check assays reported similar values but it was not uncommon to have occasional high and null assays, suggesting nugget gold. A systematic review of this issue is recommended.

During that time period, in the US, companies did not conduct systematic blank, duplicate, and standard checks on the gold assays, simply because they planned to mine the deposit themselves. Also, there were no chain of control standards, which are necessary for today's published resource reserves.

It is recommended that an attempt be made to locate and survey at least 20 % of the holes in key areas, before mining starts, with a differential gps to check accuracy of the survey of the drill collar locations. There were two different mine grid coordinate systems, the Anaconda Mine grid and the Mineral Hill Mine grid. The check would verify that each generation of drill holes were accurately surveyed and reported in the database. Many of the sites have been reclaimed but often drill casing is left buried in the ground and a metal detector and gps can sometimes verify these sites and at a minimum check, if the hole falls within a reclaimed area, there is some confidence that the survey of the collars were completed correctly.

Crevice Mountain and Tower Grove drill holes recovered in the database			
Years	**# Holes**	**Total Footage**	**Company**
1973	14	9,916.0	**Anaconda**
1979-1983	67	31,062.6	**Homestake/ Inco**
1994	70	48,650.4	**TVX**
1996	47	22,561.0	**TVX**
Total		112,190.0	

Drill logs were collected from a digital database for the 1996 holes drilled by Mine Development Associates. The earlier holes were retrieved in the 1970-1983 holes were hand entered by a college student from the original drill logs and assay sheets. The 1994 holes were converted from Notepad of the Boris files into Excel spreadsheets for future mine development use. The data was converted into collar locations, downhole surveys, rock types, and assays tables. It is strongly recommend that a check of at least 20% of these retrieved drill hole databases be done against the original drill logs and assay sheets before modeling begins, particularly the assays.

5.6 Regional Geology

The Crevice Mountain Mine lies on the southern portion of the Snowy Mountains, in the Jardine district. The Crevasses/Jardine district lies in the Beartooth Absaroka uplift in which Archean metasedimentary schist and gneiss have been uplifted, and eroded over 10,000 feet of Mesozoic and Paleozoic sediments in the late Cretaceous or Early Tertiary (Seager, 1944). The Jardine district has two structural blocks, the Mineral Hill-Jardine block and the Crevice Mountain block.

In the Jardine block, at Mineral Hill, the rocks were originally interpreted to be metasedimentary greywacke and mudstone, of at least 2660 Ma and dating of zircon by Mogk (1988) suggest an age of 3200 Ma, the oldest rocks in the Beartooth Mountains. The rocks likely formed offshore of the Archean Continent in a turbindite environment in which volcanic activity shed derived quartz, clay and feldspar were swept into offshore basins. As these basins filled, underwater hotsprings were depositing siliceous mudstone, chert, and banded iron formations with gold, arsenic, silver, and minor tungsten, copper, lead and zinc. The ages of the rocks are determined by Brooks who reports a minimum age of the Crevice Mountain granite stock at 2660 Ma with a thermal metamorphic overprint of 1600 to 1800Ma. Montgomery and Lytwyn (1984) report a Rb-Sr age of 2620 to 2760 Ma for the Crevice Mountain granite and a metamorphic reset age of 1800 Ma, and a 3000 Ma for the age of the sediments. Two ages of diabase dikes and sills intrude the Jardine mine: the oldest diabase sills are sheared and folded and there is a younger event that is undeformed; intruding after the metamorphic events. . Since the Crevice Mountain stock is said to be undeformed, the initial folding and amphibole grade metamorphic events are thought to occur between 3200 Ma and 2620 Ma. This makes the sediments in the district likely the oldest in the Beartooth Plateau, likely much older than the 3200 Ma.

The Jardine rocks are thought to be allochthonous, a terrane unique from the rest of the Beartooth Archean rocks that was tectonically emplaced against the western margin of the Archean continent. These rocks suffered a strong deformational history after being deposited upon the sea floor, they were likely subducted along this margin forming the metamorphic overprint. Jablinski and Holst (1992) report three phases of folding in the Jardine rocks with metamorphic grades reaching upper amphibolite. At Mineral Hill the gold occurs in an intensely folded (recumbent and isoclinal) iron formation that was later folded by more moderate broad open folding events. Peak metamorphic is estimated at 560˚C and pressures of 2.9 kb, which could be interpreted as a maximum burial depth of 10 km. As the rocks were accreted to the continent and uplifted, plates tectonic subduction was likely occurring beneath the metamorphic rocks causing melting; resulting in the emplacement of the Crevice Mountain granite and gabbro intrusions in the sediments. The intrusion of the granite and gabbro likely allowed for the remobilization and concentration in the iron formations, at Mineral Hill and in the veins at Crevice Mountain. The final low grade metamorphic event likely occurred at 1800 Ma. The Laramide Orogeny

(Cretaceous- Tertiary) was underlain by shallow subducting plates from the Pacific Ocean causing considerable uplift. Structural blocks appear to be controlled along northeast and northwest striking high- angle brittle faults such as the Bear Gulch and East Faults. These later brittle faults are thought to be dip slip but lack of markers across the faults elude movement definition.

At Crevice Mountain area, the host rocks have a similar metasedimentary rocks that have been metamorphosed to a greenschist-amphibolite grade. The rocks appear to have a slightly lower metamorphic grade, lacking the garnet and sillimanite seen at Mineral Hill. These rocks are intruded by the Crevice Mountain granite stock to the southwest and a gabbro intrusive to the northeast of the mine. The deformational history appears less complicated with simple boudin shearing along the bedding planes and possibly a broad gentle doming event around the gabbro intrusion, north of Tower Hill. The gold event is different in style than Mineral Hill. At Crevice, the gold is associated with clear quartz veins and quartz stock work in the quartz biotite schist. The veins occur in the Conrad zone, a 300- 400 foot wide zone of sheared quartz biotite schist. Quartz veins in the Conrad zone appear to be stacked in shear zone with at least six and possibly as many as 11 different horizons. TVX geologist interpreted these as metamorphosed exhalite chert or silica zones that were shears and metamorphosed. An alternative interpretation is they were originally emplaced as quartz veins into the sedimentary rocks as hotsprings along a fault or specific horizon. These silica exhalite or veins were recrystallized and sheared during the amphibolite grade metamorphic event. Gold is generally coarse grained and appears to be associated with the veins. Six small zones of banded iron formation are mapped in different horizons across Crevice Mountain. Minor latite or andesite porphyry dikes or sills have been noted on the Crevice property. These are intrusions likely associated with the Yellowstone volcanic rocks to the south. In two drainages, pockets of Tertiary tuffs are deposited on the Archean rocks. An unmapped major northeast striking fault (in Palmer Creek?) may exist and separate the Mineral Hill structural block from Crevice Mountain.

5.7 Deposit geology

In the Crevice deposit the gold is deposited in quartz veins and in chlorite- biotite schist zones that surround the veins. The veins average 3.5 to 4 feet in width and vary from 1.5 feet to over 12 feet in drill intercepts. Veins are deposited parallel to folitation or bedding as sheared and boudin pods and beds of silica. In a few locations gold is associated with quartz cummington schist, likely with minor quartz and/or sulfides. Seager (1944, page 44) reports quartz gold veins transitioning into granite pegmatite in the Crevices area, suggesting very high temperature vein development. Seager also notes, “From an economic standpoint, the most striking and significant feature of the veins in the district is their irregular and generally unpredictable habit as regards thickness, continuity, and grade. Veins minerals occur along the mineralized zones both as lenticular masses of extremely variable size and habit, and as associated disseminations in hydrothermally altered schist. Values in gold, tungsten, and arsenic are irregularly distributed.”

5.8 Ore zones

In the Crevice district, the historic “veins” were also called “strands,” which consist of two or more quartz veins a few inches to 10 feet in width generally 5 to 10 feet apart. These strands or “veins” are 10 to 75 feet thick in which the actual quartz gold veins are echelon within the strand. Photo shown below illustrates that sheared and boudin nature of the quartz veins in a strand. The separate “strands” or veins as they were historically called, generally exhibited more intense shearing within the strand with less deformed biotite schist around the strand. Seager, 1944 reports some strands had only 15 to 20 % quartz vein material that necessitated the need for selective mining and sorting in the strand zone. A mineralized lode can consist of a single vein with distinct wall rock but more commonly consisted of closely associated strands. The strands often are complex with the veins occurring in an echelon pattern that pinch and swell along strike and dip. The boundaries can be distinct fault/ bedding plane boundaries but also have “schist veins” in which the boundary is an economic boundary developed by the amount of sulfide and small quartz stringers with gold in the schist. Initial development work may need to drill on 25 foot to 50 foot centers to properly define these strand/ vein zones for mining.

In reviewing approximately 10 % of the “ore” / gold bearing zones in the 1994 and 1996 logs, an unusual notation of assays were noted on the drill logs, especially in vein zones that had identified visible gold. A couple of examples of merit:

Hole 96CR-30- sample 80 assayed 570.4 to 570.6 feet (0.2 feet) that contained 1.816 opt gold and the intervals below from 570.6 to 572.3 (4.4 feet) show no assay. It is possible that the 1.816 included the entire 4.6 feet but not described as such in the log.

Hole 96CR-69 assayed 238.1 to 238.7 feet (0.6 feet) with an average of 0.210 opt gold. The interval below with visible gold shows no assay from 238.7 to 239.6 feet (0.9 feet). Again it is highly likely the true interval of the assay sample was from 238.1 to 239.6 but notations on the log do not denote as such. A surprising amount of NS (none sampled) material occurred in the drill holes. In reviewing the drill logs the occurrence of visible gold usually indicted a higher grade horizon but gold grades could vary from over 1 opt to less than 0.02 opt.

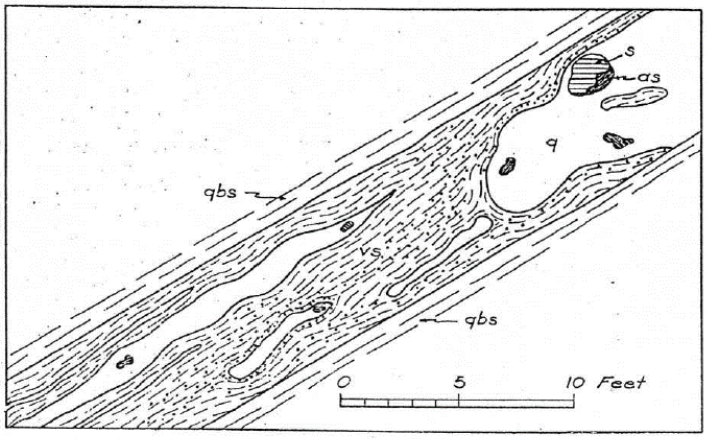
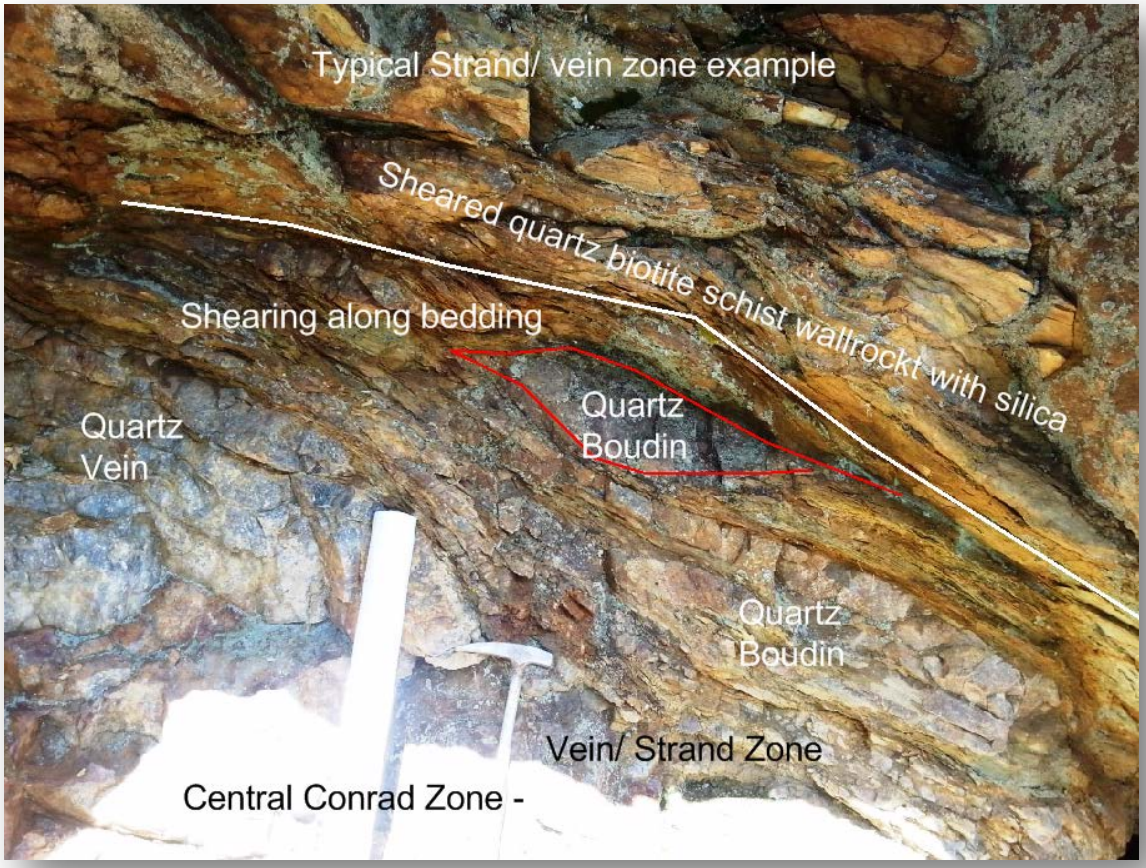


Figure 3.---Composite sketch illustrating characteristic features of No. 2 vein, Jardine mine. Vertical section perpendicular to the strike of the vein. Features shown are typical of quartz veins occurring in quartz-biotite schist (qbs). Shows lenticular form of the quartz bodies, variations in the relative amounts of quartz (q) and vein schist (vs), and the mode of occurrence of arsenopyrite (as) and scheelite (s). Modified after S. H. Cathcart.


Typical Strand/ vein zone example
Sheared quartz biotite schist waltrockt with silica
Shearing along bedding
Quartz
Vein
Quartz
Boudin
Quartz
Boudin
Vein/ Strand Zone
Central Conrad Zone -

Mineralogy- The mineralogy of the Crevice gold zones appears to be three vein types

1) Clear quartz- sulfide veins associated with strong cummingtonite schist,

2) Quartz gold veins with limited arsenopyrite and minor sulfides (pyrrhotite, pyrite, marcasite, gold and occasionally chalcopyrite, galena, and sphalerite.)

3) Oxidized quartz gold veins.

The mineralogy of these veins is well described in the attached table from Seager, 1944

Table 4

Mineral development in veins and wall rocks of the Jardine-Crevasse Mountain district

	Sedimentary deposition	Development of schist minerals*	Intrusion	First stage (silicate stage)	Second stage (sulphide-scheelite stage)	Third stage (gold stage)	Fourth stage (carbonate stage)	Period of supergene alteration
		Period of regional metamorphism		Period of hydrothermal mineralization				
			Deformation of schist**			Fracturing		
Minerals in quartz-biotite schist and biotite quartzite	Quartz Kaolin Iron oxide Feldspar Sericite Chlorite Zircon Apatite Magnetite Tourmaline ?	Quartz Biotite Chlorite Feldspar Muscovite Zircon Apatite Magnetite Tourmaline ?	Crevasse Mountain gabbro, fine-grained diabase, and granite	Quartz Biotite Garnet Muscovite Oligoclase Tourmaline Andalusite Zoisite	Quartz Arsenopyrite Pyrite Scheelite Chalcopyrite Galena Chlorite Gold	Quartz Chlorite Galena Gold	Quartz Barite (Calcite)	Calcite ? Cerussite Chalcedony Covellite (Gypsum) Limonite Marcasite Melanterite Native copper Quartz Scorodite Tungstite
Minerals in quartz-cummingtonite schist	Quartz Siderophyllite Kaolin Iron oxide	Quartz Cummingtonite Hornblende ? Magnetite		Quartz Fibrous cummingtonite Hornblende Biotite Garnet (Oligoclase) (Tourmaline)	Quartz Arsenopyrite Pyrite Scheelite Pyrrhotite Chalcopyrite Sphalerite Chlorite Gold	Quartz Chlorite Gold	Quartz Siderite (Barite) Pyrite Calcite	do + Gypsum

*Initial recrystallization under regional metamorphism to produce schist. Some minerals listed, such as the accessory minerals zircon, apatite, and perhaps tourmaline (if an original constituent), are considered to have occurred in the original sedimentry rocks, and were little affected by metamorphism.

**Deformation of schist, with development of drag folds. Granulation and recrystallization of quartz, and fracturing of early-formed sulphides and scheelite.

Note: Minerals underlined predominate; those in parentheses not observed, but probably present in subordinate amount; and those of uncertain genetic relation are questioned.

5.9 Alteration/ Wall Rock Controls

Descriptions of alteration are limited to reviews of drill logs which are mostly numeric with limited descriptions and a brief one day visit to historic surface prospects. A review of numerous 1994 and 1996 drill logs suggest that visually the gold zones may be difficult to predict unless visible gold is noted with the veins. Logging focused on the presences of quartz veins, especially with sulfides such as arsenopyrite, sphalerite, and galena. Weathering of the veins appear to be limited with sulfides noted within 50 feet of the surface, although in a few spots later weathering of sulfides to limonite and clay have been rarely noted as deep as 700 feet. Presence of biotite rich schists, grunerite, and cummingtonite schists were highlighted in logging and may prove useful markers for more productive vein/strand zones. It may be difficult to distinguish high grade veins (>0.25 opt) within the strand zone from low grade (<0.15 opt gold) simply using quartz veins and wall rock alteration simply due to the large amount of deformation and metamorphism that have altered the veins since formation. It appears that most of the gold, however, does occur with quartz veins and quartz stockwork with sulfides in the schists. More iron rich zones were highlighted by TVX geologist.

5.10 Historic Mineral Resources and Methodology

The historic resources of TVX currently do not meet the current resource reserve standards for a Canadian 43-101 compliant report because of:

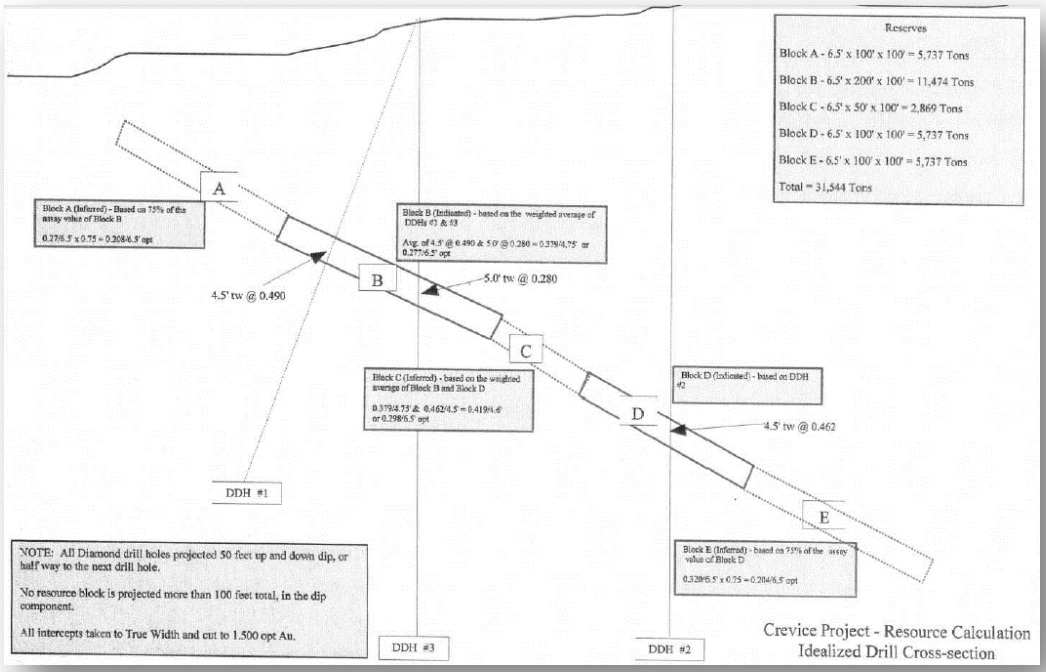
1) Lack of chain of control protocol
2) Lack of lab blanks and gold standards in the assay control,
3) Lack of defined survey control of the drill collars
4) Weak geologic structural control modelling.

Although most of these controls are not defined in the current database, during the time the work was conducted there is no reason to expect that reasonable samples protocol and collar survey control was conducted, just not defined or present in the data at hand. The lack of blanks and standards with the gold assay labs is typical of that time period and the high use of duplicate and triplicate sampling suggests that results are reasonable, although this data needs to be rigorously reviewed.

The geologic model of the current resource could be dramatically improved by conducting a detailed structural map and detailed sampling of trenches, exposed veins, and historic workings at the surface projection of the Conrad zone. This data could be used to tie and better define the proposed vein/ strand zones modelled by TVX. This data, along with the structural data collected on the drill logs for the strand zones from the core logging, could create a much tighter geologic model. The lack of structural definition in the current deposit, that is clearly structurally controlled, could present some unpleasant surprises, especially if the strand zones are faulted and displaced. In order to prepare for mining and developing ore control plans, a systematic sampling of one or more of the historic mines on 2 meter intervals with one meter long samples across the vein zones is strongly recommended.

One modelling parameter that was not checked was the conversion and dilute of the smaller veins to a 6.5 foot diluted resource model. This parameter should be checked by a detailed comparison on at least six polygonal cross section block models across the deposit to insure that the polygonal model was correctly diluted in the resource and reserve that was imported into the current 3D models.

There is some variation between the resource reported in April 1997 by TVX and the summed totals of the blocks that were imported by Mine Development Associates for this review. The variance suggest that the MDA has more resource than the TVX model. This might be due to the fact that the MDA included all the polygonal blocks on the section and in the resource report. There were clearly blocks that had been modelled that may not have been included in the resource due to mine planning or perhaps were added later as the data came in from the 1996 exploration program.



5.11 Geologic Recommendations

Mining preparation

- Detailed sampling of historic workings.
- Check the dilution polygonal estimates for tonnage and gold grade from the original drill logs and assays.
- Survey at least 20% of each phase of drill hole collars to insure proper locations.
- Plan to drill the first round of targeted ore at 50 foot centers to insure reproducibility with TVX model. If the drilling does not show reproducible and predictable results then 25 foot centers need to be drilled.
- Build a better geologic map on topography with all known drill holes in the Conrad Zone
- Plot all the roads, workings and drill holes with known gold samples on the surface and geologic.
- Build better detailed structural model on cross and long sections (on at least 100 foot centers) and plan maps in the first three years planned to be mined.

Converting to public reserve

- The work above is strongly recommend as a first step to building a better geologic model for reserves.
- At least 15% of the historic drilling would need to be re-drilled and tested using compliant quality control to convert the current deposit into a resource.
- To convert the resource to a reserve, mining a portion of the deposit would be instrumental in having a third part sign off to demonstrate economic viability.
- One might consider twinning 6 to 10 core holes with surveyed RC (reverse circulation) drilling that is conducted at 1 meter intervals. The deposit appears to have very competent rock with small amounts of water, with limited opportunities for downhole contamination from RC drilling. RC drilling offers a larger diameter and thus a larger sample through the deposit which could improve the predictability of the gold in the strand zones. There are sluice boxes that test the waste coming off the RC rigs now that offer over 150 pound test sample on each 5 foot interval which is very attractive in defining coarse gold zones. If the RC drilling gave good drill results, then expansion drilling cost could be cut by 60 to70%.

Drilling recommendations

- An additional 40,000 feet of drilling would test the up dip extensions of current resource, which is to be mined in the near future. This will not likely double the resource but would dramatically expand the current planned resource. This might be as viable from an underground platform as part of resource development.

5.12 Exploration Potential/ Recommendations

The exploration potential of the Crevice Mountain project is very good. The current resource was drilled to be exploited by an underground tunnel from Mineral Hill. Consequently, most of the defined resource starts 200 to 400 feet down dip of the historic structures and was drilled on about a 300 to 400 foot down dip extensions. Surprisingly, the easiest gold zone to test from the surface down to the resource was not drilled and barely sampled at the surface, though good veins and historic workings offer ample opportunity to expand the zones. The sampling that was conducted at the surface and limited historic workings seem to line up very well with the “vein zones” defined by TVX. The current “resource” defined by TVX is said to be just over 490,000 ounces. If this zone is drilled to the surface, and extended down dip 300 to 400 feet, it is not unreasonable to expect this resource, using the same modelling parameters as TVX, could easily exceed 1 million ounces.

Work conducted by TVX, Homestake, and Inco defined over six stacked BIF horizons with large soil and geophysical anomalies in the Tower Grove, Buffalo Mountain, and West Buffalo Mountain areas that suggest other gold veins are likely present. The mineral rights over these anomalies should be acquired as they represent the opportunity to grow this project into a multimillion ounce gold district.

The challenge at Crevice Mountain is not to find additional gold, but to actually develop the mining techniques that can economically extract the gold from the Conrad zone which currently is the most attractive gold zone. The narrow and erratic nature of the sheared vein zones/ strands and the lack of

water to process the ore limited development in the 1900s and is still the challenge today. Once the mining of the current deposit is defined to be profitable, then exploration could proceed to expand the resources in the district to well over 1 million ounces.

Exploration recommendations:

- Convert the current geochemical and geophysical data into a GPS compatible database so property boundaries, topography, and geology can be compared.
- Detailed structural mapping of the Conrad zone and historic workings.
- Detailed sampling of historic workings.
- Black light historic workings to determine the amount of scheelite present with the gold zones.
- Trench in planned waste dump area and sample before stacking waste to prevent burying easily accessible high grade gold veins that could be extracted before the waste dumps are built.
- Dig hand dug trenches in up dip vein zones in areas with little or no soil and sample the exposed veins.

References

Davis, N. F., 1977, Geochemical Gold Survey Surveys of the Jardine- Crevice Mountain District, Park Co., Montana between1974 to 1977, Interim report for Homestake Mining Company, Private report.

Jablinski, J. D. and Holst, T. H., 1992, Deformational History of Archean Metasedimentary Rocks of the Beartooth Mountains in the Vicinity of the Mineral Hill Mine, Jardine, Montana, The Journal of Geology, volume 100 p.561-578.

Montgomery, C.W., and Lytwyn, J.N., 1984, Rb-Sr systematics and ages of principle Precambrian Lithologies in the South Snowy Block, Beartooth Mountains: Journal of Geology, v. 92, p.103-112.

Mogk, D. W., 1988, Archean allochthounous units in the Northern and Western Beartooth Mountains, Montana: Montana Bureau of Mines and Geology Special Publication 96, p. 43-51.

Seagar, George F., 1944, Arsenic, Gold, and Tungsten Deposits of the Jardine and Crevasse Mountain District, Park County, Montana, Montana Bureau of Mines and Geology, Memoir 23, 111p.

Appendix B : Well and Water Data

Appendix B-1:

GWIC
Laubach and Johnson Well Logs

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Go to GWIC website
View scanned well log (3/25/2010 11:57:09 AM)

Site Name: LAUBACH DON
GWIC Id: 105997
DNRC Water Right: C072046-00

Section 1: Well Owner(s)

1) LAUBACH, DON (MAIL)
N/A
GARDINER MT 59030 [07/17/1989]

Section 2: Location

Township	Range	Section	Quarter Sections
09S	09E	15	SE¼ SE¼ SE¼

County
PARK

Geocode

Latitude	Longitude	Geomethod	Datum
45.043691	110.596596	TRS-SEC	NAD83

Ground Surface Altitude **Method** **Datum** **Date**

Addition **Block** **Lot**
MINERAL SURVEY #9681

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Monday, July 17, 1989

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	165	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
0	18.5	6				STEEL
18.5	165	4				PVC

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
165	165	4			OPEN BOTTOM *

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	20	BENTONITE	

Section 7: Well Test Data

Total Depth: 165
Static Water Level: 83
Water Temperature:

Air Test *

1 gpm with drill stem set at _ feet for 1 hours.
Time of recovery 1 hours.
Recovery water level 83 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source
500PRBL - PRE-BELT

From	To	Description
0	7	SAND
7	165	SCHIST ROCK

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: VAN DYKEN DRILLING INC
License No: WWC-380
Date Completed: 7/17/1989

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Go to GWIC website
View scanned well log (3/25/2010 11:58:25 AM)

Site Name: JOHNSON WARREN
GWIC Id: 175267
DNRC Water Right: C108912

Section 1: Well Owner(s)

1) JOHNSON, WARREN (WELL)
162 CREVICE MOUNTAIN RD
GARDINER MT 59030 [01/01/2009]
2) JOHNSON, WARREN (MAIL)
BOX 399
GARDINER MT 59030 [08/30/1999]

Section 2: Location

Township	Range	Section	Quarter Sections
09S	09E	16	NW¼ SW¼ NE¼ SW¼

County PARK
Geocode

Latitude	Longitude	Geomethod	Datum
45.047837	110.630651	TRS-SEC	NAD83

Ground Surface Altitude **Method** **Datum** **Date**

Addition **Block** **Lot**

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: REPLACEMENT
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Monday, August 30, 1999

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	195	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	180	6	0.250		WELDED	STEEL
170	190	4		160.00		PLASTIC

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
170	190	4		.025X1 IN	FACTORY SLOTTED

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	BENTONITE	Y

Section 7: Well Test Data

Total Depth: 195
Static Water Level: 65
Water Temperature:

Air Test *

20 gpm with drill stem set at 180 feet for 2 hours.
Time of recovery 1 hours.
Recovery water level 65 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source
Unassigned

From	To	Description
0	29	LARGE BOULDERS GRAVEL AND CLAY
29	95	SOFT SANDY CLAYS WITH SOME GRAVELS AND BOULDERS
95	120	CLAY BOUND GRAVELS AND FEW BOULDERS
120	185	SANDY CLAYS GRAVEL AND FEW BOULDERS
185	195	BROKEN UP BEDROCK BLACK GRANITE

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 8/30/1999

Appendix B-2:

Surface Runoff Water Sample Data - 2015
Collected 200 feet north of the Proposed Portal

ANALYTICAL SUMMARY REPORT

June 17, 2015

Pioneer Technical Services
1101 S Montana St
Butte, MT 59701-2857

Work Order: H15060103

Project Name: Crevice Mining Group - Exploration

Energy Laboratories Inc Helena MT received the following 1 sample for Pioneer Technical Services on 6/4/2015 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
H15060103-001	CMB-PROPWell-1_RAW	06/03/15 13:00	06/04/15	Aqueous	Metals by ICP/ICPMS, Tot. Rec. Alkalinity Conductivity Mercury, Total Recoverable Anions by Ion Chromatography pH Metals Digestion by EPA 200.2 Digestion, Mercury by CVAA

The analyses presented in this report were performed by Energy Laboratories, Inc., 3161 E. Lyndale Ave., Helena, MT 59604, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Helena, MT Branch

Client: Pioneer Technical Services
Project: Crevice Mining Group - Exploration
Lab ID: H15060103-001
Client Sample ID: CMB-PROPWell-1_RAW

Report Date: 06/17/15
Collection Date: 06/03/15 13:00
DateReceived: 06/04/15
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.3	s.u.	H	0.1		A4500-H B	06/05/15 14:48 / SRW
Conductivity @ 25 C	65	umhos/cm		1		A2510 B	06/05/15 14:48 / SRW
INORGANICS							
Alkalinity, Total as CaCO3	31	mg/L		4		A2320 B	06/08/15 13:17 / SRW
Bicarbonate as HCO3	38	mg/L		4		A2320 B	06/08/15 13:17 / SRW
Carbonate as CO3	ND	mg/L		4		A2320 B	06/08/15 13:17 / SRW
Chloride	ND	mg/L		1		E300.0	06/05/15 21:51 / SRW
Sulfate	ND	mg/L		1		E300.0	06/05/15 21:51 / SRW
METALS, TOTAL RECOVERABLE							
Aluminum	0.21	mg/L		0.03		E200.8	06/15/15 22:16 / dck
Arsenic	0.003	mg/L		0.001		E200.8	06/15/15 22:16 / dck
Cadmium	ND	mg/L		0.001		E200.8	06/15/15 22:16 / dck
Calcium	9	mg/L		1		E200.7	06/09/15 13:45 / sld
Chromium	ND	mg/L		0.005		E200.8	06/15/15 22:16 / dck
Copper	ND	mg/L		0.005		E200.8	06/15/15 22:16 / dck
Iron	0.19	mg/L		0.02		E200.8	06/15/15 22:16 / dck
Lead	ND	mg/L		0.001		E200.8	06/15/15 22:16 / dck
Magnesium	2	mg/L		1		E200.7	06/09/15 13:45 / sld
Manganese	0.002	mg/L		0.001		E200.8	06/15/15 22:16 / dck
Mercury	ND	mg/L		0.0001		E245.1	06/10/15 16:08 / rgk
Potassium	1	mg/L		1		E200.7	06/10/15 12:38 / sld
Silver	ND	mg/L		0.001		E200.8	06/15/15 22:16 / dck
Sodium	2	mg/L		1		E200.7	06/09/15 13:45 / sld
Zinc	ND	mg/L		0.01		E200.8	06/15/15 22:16 / dck

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2320 B										Batch: R106663
Lab ID: MB		Method Blank				Run: PHSC_101-H_150608A				06/08/15 13:01
Alkalinity, Total as CaCO3		2	mg/L	0.7						
Lab ID: LCS		Laboratory Control Sample				Run: PHSC_101-H_150608A				06/08/15 13:06
Alkalinity, Total as CaCO3		590	mg/L	4.0	98	90	110			
Lab ID: H15060103-001ADUP	3	Sample Duplicate				Run: PHSC_101-H_150608A				06/08/15 13:22
Alkalinity, Total as CaCO3		32	mg/L	4.0				2.0	10	
Bicarbonate as HCO3		38	mg/L	4.0				2.1	10	
Carbonate as CO3		0.30	mg/L	4.0					10	
Lab ID: H15060126-012AMS		Sample Matrix Spike				Run: PHSC_101-H_150608A				06/08/15 14:59
Alkalinity, Total as CaCO3		820	mg/L	4.0	95	80	120			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: A2510 B										Batch: R106632
Lab ID: SC 150		Initial Calibration Verification Standard				Run: PHSC_101-H_150605A				06/05/15 08:21
Conductivity @ 25 C		150	umhos/cm	1.0	100	90	110			
Lab ID: SC 5000		Initial Calibration Verification Standard				Run: PHSC_101-H_150605A				06/05/15 08:24
Conductivity @ 25 C		4980	umhos/cm	1.0	100	90	110			
Lab ID: SC 20000		Initial Calibration Verification Standard				Run: PHSC_101-H_150605A				06/05/15 08:26
Conductivity @ 25 C		19600	umhos/cm	1.0	98	90	110			
Lab ID: SC 2ND 1000		Laboratory Control Sample				Run: PHSC_101-H_150605A				06/05/15 08:28
Conductivity @ 25 C		1010	umhos/cm	1.0	101	90	110			
Lab ID: H15060103-001ADUP		Sample Duplicate				Run: PHSC_101-H_150605A				06/05/15 14:50
Conductivity @ 25 C		65.0	umhos/cm	1.0				0.0	10	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: **A4500-H B**								Analytical Run: PHSC_101-H_150605A		
Lab ID: **pH 7**		Initial Calibration Verification Standard							06/05/15 08:19	
pH		7.0	s.u.	0.1	100	98	102			
Method: **A4500-H B**									Batch: R106632	
Lab ID: **H15060103-001ADUP**		Sample Duplicate				Run: PHSC_101-H_150605A			06/05/15 14:50	
pH		7.3	s.u.	0.1				0.1	3	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**E200.7**									Analytical Run: ICP2-HE_150609B	
Lab ID:	**ICV**	3	Initial Calibration Verification Standard							06/09/15 10:59	
Calcium			41.7	mg/L	1.0	104	95	105			
Magnesium			41.3	mg/L	1.0	103	95	105			
Sodium			39.8	mg/L	1.0	99	95	105			
Lab ID:	**CCV-1**	3	Continuing Calibration Verification Standard							06/09/15 11:03	
Calcium			26.1	mg/L	1.0	104	95	105			
Magnesium			25.7	mg/L	1.0	103	95	105			
Sodium			24.3	mg/L	1.0	97	95	105			
Lab ID:	**ICSA**	3	Interference Check Sample A							06/09/15 11:14	
Calcium			477	mg/L	1.0	95	80	120			
Magnesium			517	mg/L	1.0	103	80	120			
Sodium			0.0495	mg/L	1.0		0	0			
Lab ID:	**ICSAB**	3	Interference Check Sample AB							06/09/15 11:18	
Calcium			495	mg/L	1.0	99	80	120			
Magnesium			527	mg/L	1.0	105	80	120			
Sodium			20.4	mg/L	1.0	102	80	120			
Lab ID:	**CCV**	3	Continuing Calibration Verification Standard							06/09/15 13:19	
Calcium			26.6	mg/L	1.0	106	90	110			
Magnesium			26.8	mg/L	1.0	107	90	110			
Sodium			26.0	mg/L	1.0	104	90	110			
Method:	**E200.7**									Batch: 29197	
Lab ID:	**MB-29197**	4	Method Blank				Run: ICP2-HE_150609B			06/09/15 13:38	
Calcium			0.08	mg/L	0.06						
Magnesium			0.01	mg/L	0.01						
Potassium			ND	mg/L	0.07						
Sodium			0.03	mg/L	0.01						
Lab ID:	**LCS-29197**	4	Laboratory Control Sample				Run: ICP2-HE_150609B			06/09/15 13:42	
Calcium			27.9	mg/L	1.0	111	85	115			
Magnesium			28.5	mg/L	1.0	114	85	115			
Potassium			27.7	mg/L	1.0	111	85	115			
Sodium			27.4	mg/L	1.0	109	85	115			
Lab ID:	**H15060103-001BDIL**	4	Serial Dilution				Run: ICP2-HE_150609B			06/09/15 13:49	
Calcium			10.4	mg/L	1.0		0	0	13	10	R
Magnesium			2.47	mg/L	1.0		0	0		10	N
Potassium			ND	mg/L	1.0		0	0		10	
Sodium			2.27	mg/L	1.0		0	0	1.5	10	
Lab ID:	**H15060103-001BMS3**	4	Sample Matrix Spike				Run: ICP2-HE_150609B			06/09/15 13:53	
Calcium			63.6	mg/L	1.0	109	70	130			
Magnesium			59.1	mg/L	1.0	114	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

N - The analyte concentration was not sufficiently high to calculate a RPD for the serial dilution test.

R - RPD exceeds advisory limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.7										Batch: 29197
Lab ID: H15060103-001BMS3	4	Sample Matrix Spike				Run: ICP2-HE_150609B			06/09/15 13:53	
Potassium		55.9	mg/L	1.0	109	70	130			
Sodium		55.8	mg/L	1.0	107	70	130			
Lab ID: H15060103-001BMSD	4	Sample Matrix Spike Duplicate				Run: ICP2-HE_150609B			06/09/15 13:57	
Calcium		63.5	mg/L	1.0	109	70	130	0.2	20	
Magnesium		58.8	mg/L	1.0	113	70	130	0.4	20	
Potassium		55.3	mg/L	1.0	108	70	130	1.2	20	
Sodium		55.0	mg/L	1.0	105	70	130	1.3	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**E200.7**									Analytical Run: ICP2-HE_150610B	
Lab ID:	**ICV**		Initial Calibration Verification Standard							06/10/15 11:26	
Potassium			40.8	mg/L	1.0	102	95	105			
Lab ID:	**CCV-1**		Continuing Calibration Verification Standard							06/10/15 11:30	
Potassium			25.6	mg/L	1.0	103	95	105			
Lab ID:	**ICSA**		Interference Check Sample A							06/10/15 11:41	
Potassium			-0.119	mg/L	1.0		0	0			
Lab ID:	**ICSAB**		Interference Check Sample AB							06/10/15 11:45	
Potassium			21.0	mg/L	1.0	105	80	120			
Lab ID:	**CCV**		Continuing Calibration Verification Standard							06/10/15 12:15	
Potassium			25.4	mg/L	1.0	102	90	110			
Method:	**E200.7**									Batch: 29197	
Lab ID:	**MB-29197**	4	Method Blank				Run: ICP2-HE_150610B			06/10/15 12:31	
Calcium			0.09	mg/L	0.06						
Magnesium			ND	mg/L	0.02						
Potassium			ND	mg/L	0.07						
Sodium			ND	mg/L	0.01						
Lab ID:	**LCS-29197**	4	Laboratory Control Sample				Run: ICP2-HE_150610B			06/10/15 12:35	
Calcium			27.8	mg/L	1.0	111	85	115			
Magnesium			28.3	mg/L	1.0	113	85	115			
Potassium			27.4	mg/L	1.0	110	85	115			
Sodium			27.7	mg/L	1.0	111	85	115			
Lab ID:	**H15060103-001BDIL**	4	Serial Dilution				Run: ICP2-HE_150610B			06/10/15 12:42	
Calcium			9.69	mg/L	1.0		0	0	9.0	10	
Magnesium			2.39	mg/L	1.0		0	0	7.8	10	
Potassium			ND	mg/L	1.0		0	0		10	
Sodium			2.13	mg/L	1.0		0	0	9.9	10	
Lab ID:	**H15060103-001BMS3**	4	Sample Matrix Spike				Run: ICP2-HE_150610B			06/10/15 12:46	
Calcium			63.8	mg/L	1.0	110	70	130			
Magnesium			58.3	mg/L	1.0	112	70	130			
Potassium			57.1	mg/L	1.0	112	70	130			
Sodium			58.5	mg/L	1.0	112	70	130			
Lab ID:	**H15060103-001BMSD**	4	Sample Matrix Spike Duplicate				Run: ICP2-HE_150610B			06/10/15 12:50	
Calcium			63.5	mg/L	1.0	109	70	130	0.5	20	
Magnesium			57.9	mg/L	1.0	111	70	130	0.6	20	
Potassium			57.2	mg/L	1.0	112	70	130	0.1	20	
Sodium			58.6	mg/L	1.0	113	70	130	0.3	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8								Analytical Run: ICPMS204-B_150615A		
Lab ID: ICV STD	10	Initial Calibration Verification Standard								06/15/15 19:39
Aluminum		0.313	mg/L	0.10	104	90	110			
Arsenic		0.0615	mg/L	0.0050	102	90	110			
Cadmium		0.0313	mg/L	0.0010	104	90	110			
Chromium		0.0618	mg/L	0.010	103	90	110			
Copper		0.0628	mg/L	0.010	105	90	110			
Iron		0.324	mg/L	0.020	108	90	110			
Lead		0.0593	mg/L	0.010	99	90	110			
Manganese		0.310	mg/L	0.010	103	90	110			
Silver		0.0290	mg/L	0.0050	97	90	110			
Zinc		0.0637	mg/L	0.010	106	90	110			
Lab ID: ICSA	10	Interference Check Sample A								06/15/15 19:42
Aluminum		39.6	mg/L	0.10	99	70	130			
Arsenic		0.000160	mg/L	0.0050						
Cadmium		0.000336	mg/L	0.0010						
Chromium		0.00110	mg/L	0.010						
Copper		0.000420	mg/L	0.010						
Iron		103	mg/L	0.020	103	70	130			
Lead		0.000261	mg/L	0.010						
Manganese		0.000378	mg/L	0.010						
Silver		0.000108	mg/L	0.0050						
Zinc		0.000738	mg/L	0.010						
Lab ID: ICSAB	10	Interference Check Sample AB								06/15/15 19:46
Aluminum		39.3	mg/L	0.10	98	70	130			
Arsenic		0.0109	mg/L	0.0050	109	70	130			
Cadmium		0.0108	mg/L	0.0010	108	70	130			
Chromium		0.0234	mg/L	0.010	117	70	130			
Copper		0.0212	mg/L	0.010	106	70	130			
Iron		102	mg/L	0.020	102	70	130			
Lead		0.000244	mg/L	0.010		0	0			
Manganese		0.0225	mg/L	0.010	113	70	130			
Silver		0.0184	mg/L	0.0050	92	70	130			
Zinc		0.0110	mg/L	0.010	110	70	130			
Method: E200.8										Batch: 29197
Lab ID: MB-29197	14	Method Blank				Run: ICPMS204-B_150615A				06/15/15 22:03
Aluminum		0.006	mg/L	0.002						
Arsenic		0.0001	mg/L	6E-05						
Cadmium		ND	mg/L	1E-05						
Calcium		0.04	mg/L	0.008						
Chromium		ND	mg/L	0.0001						
Copper		0.0007	mg/L	0.0002						
Iron		0.008	mg/L	0.002						
Lead		4E-05	mg/L	3E-05						

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Batch: 29197
Lab ID: MB-29197	14	Method Blank				Run: ICPMS204-B_150615A				06/15/15 22:03
Magnesium		0.01	mg/L	0.006						
Manganese		ND	mg/L	0.0002						
Potassium		0.02	mg/L	0.02						
Silver		8E-05	mg/L	5E-05						
Sodium		0.3	mg/L	0.004						
Zinc		0.004	mg/L	0.002						
Lab ID: LCS-29197	14	Laboratory Control Sample				Run: ICPMS204-B_150615A				06/15/15 22:07
Aluminum		2.76	mg/L	0.030	110	85	115			
Arsenic		0.543	mg/L	0.0010	109	85	115			
Cadmium		0.262	mg/L	0.0010	105	85	115			
Calcium		28.8	mg/L	1.0	115	85	115			
Chromium		0.545	mg/L	0.0050	109	85	115			
Copper		0.540	mg/L	0.0050	108	85	115			
Iron		2.76	mg/L	0.020	110	85	115			
Lead		0.510	mg/L	0.0010	102	85	115			
Magnesium		28.2	mg/L	1.0	113	85	115			
Manganese		2.58	mg/L	0.0010	103	85	115			
Potassium		28.8	mg/L	1.0	115	85	115			
Silver		0.0499	mg/L	0.0010	100	85	115			
Sodium		28.0	mg/L	1.0	111	85	115			
Zinc		0.526	mg/L	0.010	105	85	115			
Lab ID: H15060103-001BMS3	14	Sample Matrix Spike				Run: ICPMS204-B_150615A				06/15/15 22:19
Aluminum		5.53	mg/L	0.030	106	70	130			
Arsenic		1.05	mg/L	0.0010	105	70	130			
Cadmium		0.521	mg/L	0.0010	104	70	130			
Calcium		63.8	mg/L	1.0	110	70	130			
Chromium		1.06	mg/L	0.0050	106	70	130			
Copper		1.05	mg/L	0.0050	105	70	130			
Iron		5.40	mg/L	0.020	104	70	130			
Lead		0.998	mg/L	0.0010	100	70	130			
Magnesium		56.9	mg/L	1.0	109	70	130			
Manganese		5.05	mg/L	0.0010	101	70	130			
Potassium		55.9	mg/L	1.0	109	70	130			
Silver		0.0986	mg/L	0.0010	98	70	130			
Sodium		56.5	mg/L	1.0	108	70	130			
Zinc		1.03	mg/L	0.010	102	70	130			
Lab ID: H15060103-001BMSD	14	Sample Matrix Spike Duplicate				Run: ICPMS204-B_150615A				06/15/15 22:22
Aluminum		5.59	mg/L	0.030	108	70	130	1.2	20	
Arsenic		1.06	mg/L	0.0010	105	70	130	0.2	20	
Cadmium		0.523	mg/L	0.0010	105	70	130	0.4	20	
Calcium		64.8	mg/L	1.0	112	70	130	1.5	20	
Chromium		1.06	mg/L	0.0050	106	70	130	0.4	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte	Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E200.8										Batch: 29197
Lab ID: H15060103-001BMSD	14	Sample Matrix Spike Duplicate				Run: ICPMS204-B_150615A			06/15/15 22:22	
Copper		1.06	mg/L	0.0050	106	70	130	1.1	20	
Iron		5.45	mg/L	0.020	105	70	130	1.0	20	
Lead		1.02	mg/L	0.0010	102	70	130	1.7	20	
Magnesium		57.6	mg/L	1.0	111	70	130	1.1	20	
Manganese		5.07	mg/L	0.0010	101	70	130	0.4	20	
Potassium		57.1	mg/L	1.0	111	70	130	2.1	20	
Silver		0.0986	mg/L	0.0010	98	70	130	0.1	20	
Sodium		57.0	mg/L	1.0	109	70	130	0.8	20	
Zinc		1.05	mg/L	0.010	104	70	130	1.3	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**E245.1**							Analytical Run: HGCV202-H_150610A			
Lab ID:	**ICV**		Initial Calibration Verification Standard							06/10/15 11:27	
Mercury			0.00020	mg/L	0.00010	102	90	110			
Lab ID:	**CCV1**		Continuing Calibration Verification Standard							06/10/15 11:30	
Mercury			0.00020	mg/L	0.00010	99	95	105			
Lab ID:	**CCV**		Continuing Calibration Verification Standard							06/10/15 15:24	
Mercury			0.00021	mg/L	0.00010	105	90	110			
Method:	**E245.1**										Batch: 29212
Lab ID:	**MB-29212**		Method Blank				Run: HGCV202-H_150610A			06/10/15 15:35	
Mercury			1.0E-06	mg/L	1E-06						
Lab ID:	**LCS-29212**		Laboratory Control Sample				Run: HGCV202-H_150610A			06/10/15 15:38	
Mercury			0.00014	mg/L	0.00010	93	90	110			
Lab ID:	**H15060094-005CMS**		Sample Matrix Spike				Run: HGCV202-H_150610A			06/10/15 15:46	
Mercury			0.00014	mg/L	0.00010	92	70	130			
Lab ID:	**H15060094-005CMSD**		Sample Matrix Spike Duplicate				Run: HGCV202-H_150610A			06/10/15 15:50	
Mercury			0.00014	mg/L	0.00010	93	70	130	1.1	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Helena, MT Branch

Client: Pioneer Technical Services **Report Date:** 06/17/15

Project: Crevice Mining Group - Exploration **Work Order:** H15060103

Analyte		Count	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**E300.0**									Analytical Run: IC102-H_150605A	
Lab ID:	**ICV**	2	Initial Calibration Verification Standard							06/05/15 16:06	
Chloride			103	mg/L	1.0	103	90	110			
Sulfate			412	mg/L	1.0	103	90	110			
Lab ID:	**CCV060515-2**	2	Continuing Calibration Verification Standard							06/05/15 20:11	
Chloride			102	mg/L	1.0	102	90	110			
Sulfate			414	mg/L	1.0	104	90	110			
Method:	**E300.0**									Batch: R106675	
Lab ID:	**ICB**	2	Method Blank				Run: IC102-H_150605A			06/05/15 16:18	
Chloride			0.10	mg/L	0.010						
Sulfate			0.2	mg/L	0.009						
Lab ID:	**LFB**	2	Laboratory Fortified Blank				Run: IC102-H_150605A			06/05/15 16:29	
Chloride			48.0	mg/L	1.0	96	90	110			
Sulfate			195	mg/L	1.0	98	90	110			
Lab ID:	**H15060103-001AMS**	2	Sample Matrix Spike				Run: IC102-H_150605A			06/05/15 22:02	
Chloride			47.0	mg/L	1.0	94	90	110			
Sulfate			194	mg/L	1.0	97	90	110			
Lab ID:	**H15060103-001AMSD**	2	Sample Matrix Spike Duplicate				Run: IC102-H_150605A			06/05/15 22:13	
Chloride			47.0	mg/L	1.0	94	90	110	0.1	20	
Sulfate			195	mg/L	1.0	97	90	110	0.5	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Work Order Receipt Checklist

Pioneer Technical Services

H15060103

Login completed by: Tracy L. Lorash
Reviewed by: BL2000\rwilliams
Reviewed Date: 6/9/2015

Date Received: 6/4/2015
Received by: jcm
Carrier name: Hand Del

Shipping container/cooler in good condition?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☐	No ☑	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	16.8°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☑	Not Applicable ☐

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

Sample ID on COC is CMG-PROPWell-1_RAW -ID on bottle does not include underscore. Logged in with ID from COC.
Metals sample was subsampled and preserved with 2 mL nitric acid upon receipt to pH <2 in the laboratory. In accordance with the Clean Water Act, these samples must be held for 24 hours prior to analysis. tl 6/4/15

ENERGY LABORATORIES

Chain of Custody and Analytical Request Record

Page _____ of _____

PLEASE PRINT (Provide as much information as possible.)

Company Name: Pioneer Technical Services

Project Name, PWS, Permit, Etc.: Crevice Mining Group - Exploration

Sample Origin: State: MT

EPA/State Compliance: Yes ● No ○

Report Mail Address (Required):
Pioneer Technical Services
201 East Broadway
Helena, MT 59601

☐ No Hard Copy Email: plemieux@pioneer-technical.com

Contact Name: Pierre LeMieux
Phone/Fax: (406) 457-8252
Cell: (406) 461-3703

Sampler: (Please Print)

Invoice Contact & Phone: Dana Bunny (406) 782-5177

Purchase Order:

Quote/Bottle Order:

Invoice Address (Required):
Pioneer Technical Services
1100 South Montana
Butte, MT 59701

☐ No Hard Copy Email:

Special Report/Formats:
☐ DW
☐ POTW/WWTP
☐ State: _____
☐ Other: _____
☐ EDD/EDT (Electronic Data)
Format: _____
☐ LEVEL IV
☐ NELAC

ANALYSIS REQUESTED

SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX (Number of Containers; Sample Type: A W S V B O DW; Air Water Soils/Solids Vegetation Bioassay Other DW - Drinking Water)	Common Ions/Pysiochemcial	pH	EC	Total Recoverable Al, As, Cu, Cr, Cd, Fe, Mn, Pb, Hg, Ag, Zn						SEE ATTACHED	Standard Turnaround (TAT)	RUSH
1 CMG - PROPWell - 1_RAW	6/3/15	13:00	1-W	★	★	★	★							●	○
2														○	○
3														○	○
4														●	○
5														●	○
6														●	○
7														●	○
8														●	○
9														○	○
10														○	○

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments:

LABORATORY USE ONLY

Shipped by: hand

Cooler ID(s): N

Receipt Temp: 16.8 °C

On Ice: Y (N)

Custody Seal
On Bottle Y (N)
On Cooler Y (N)

Intact Y N

Signature Match Y N

H15060103

Custody Record MUST be Signed

Relinquished by (print): Pierre LeMieux Date/Time: 6-4-15 11:20 AM Signature: P LeMieux

Relinquished by (print): Date/Time: Signature:

Received by (print): Date/Time: Signature:

Received by (print): Date/Time: Signature:

Received by Laboratory: Jan Miller Date/Time: 6/4/15 1120 Signature: Jan Miller

Sample Disposal: Return to Client: ○ Lab Disposal: ○

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

Appendix B-3:

Abstract: *A Critical Review of Static Geochemical Test Methods Applied to Mining Wastes, Including Their Applicability to Field Conditions*

By Pierre D S Rousseau

A critical review of static geochemical test methods applied to mining wastes, including their applicability to field conditions

Pierre D S Rousseau

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Abstract

Assessments for Acid Mine Drainage (AMD) and metal leaching potential for mining projects use several static geochemical test methods to measure different parameters. These tests are generally developed in a laboratory and are often subject to uncertainty and are representative of closed systems.

Issues commonly ignored or misunderstood during ARD assessments, related to acid base accounting (ABA), net acid generation (NAG) and leach tests are discussed along with some of the practical implications for sample classification under field conditions.

These issues are implicitly recognised in several review and guideline documents, but are often not adequately evaluated for mining projects.

Keywords: static geochemical testing, acid base accounting (ABA), Net Acid Generation (NAG), Synthetic Precipitation Leaching Procedure (SPLP), Acid Mine Drainage (AMD).

Introduction

Static geochemical testing is used as an important part of characterising mine wastes. Several screening tools are used in an attempt to rapidly and cheaply measure inherent geochemical properties of the materials of interest, including the potential to release acidity, metals or salinity. Generally a suite of methods is recommended, as no one method is considered reliable on its own (Price 2009, Morin & Hutt 2001, White et al. 1999, Maest & Kuipers 2005, GARD Guide).

This paper focuses on Acid Base Accounting (ABA), Net Acid Generation (NAG) Testing and leach testing for metals, as these tests are frequently the point of departure for an AMD assessment but can easily lead to erroneous conclusions by inappropriately qualified or inexperienced practitioners.

Despite most guideline documents recommending specific test methods and classification criteria, almost all of them agree that both the acid potential (AP) and the neutralising potential (NP) (or NAG potential) of a sample are unlikely to be accurately measured without a good understanding of sample mineralogy. Some of these limitations are discussed, along with the implications of currently used classification criteria and the effect of field conditions on the ABA classification criteria.

Methods

Several guideline documents and reviews were evaluated for this paper, including Price 2009, Morin & Hutt 2001, Maest & Kuipers 2005, White et al. 1999, Jambor 2003 and INAP 2012.

Discussion

The methods used for ABA testing rely on the measurement of different sulphur species to quantify the sample AP. All methods assume that acidity originates exclusively from the mineral pyrite. This can be an accurate assumption, but particularly in hard rock mining environments several other sulphide minerals may be present, which can produce variable amounts of acidity per mole of sulphide, less than or equal to pyrite. These other minerals can have a bearing on the result but are often ignored as the assumption that pyrite is present is considered to be conservative from an environmental point of view. From an economic point of view, however, if they make up a significant proportion of a sample, it may be erroneously classified as potentially acid forming (PAF).

The NP of a sample is measured by titrating it against an acid (different strengths of HCl are used for the most commonly used methods). The oldest, most common method in current use is the Sobek (1978) method, which is favoured due to its low cost, short timeframe and long history. The "modified method" is favoured by many practitioners currently (Price 2009) as it is considered more accurate and less likely to overestimate NP than the Sobek (1978) method. According to data presented by Lawrence and Wang (1997), overestimation of NP by more than 50% can occur by the Sobek (1978) method. Jambor 2003 reported that the modified method can yield higher NP than the Sobek (1978) method if a final pH <2 occurs, although such results are excluded by the method description.

Both the Sobek (1978) and modified methods use HCl to dissolve the test samples (between 0.1N and 1N, depending on the "fizz ratings). These acid solutions would have a pH of between 0.08 and 1.1 according to speciation calculations carried out for this paper with Geochemist's Workbench (thermo.dat database). This implies that any minerals that buffer acidity between the pH of the acid and the back titration could contribute to the measured ANC, depending on the sample mineralogy. The risk is limited somewhat for the modified procedure, as a final target pH of >2 is required, however, this pH is still well below pH 6, which would be considered environmentally acceptable (Price 2009, Jambor 2003, Morin & Hutt 2001). The modified method has a titration pH of 8.3, which is considered to provide a more reliable NP than the pH 7 endpoint of the Sobek (1978) test because Fe^{2+} can remain in solution below pH 8.3. At the pH 7 titration endpoint of the Sobek (1978) test, peroxide oxidation can be used to oxidised remaining Fe^{2+} in solution, although this is a modification of the standard procedure (Price 2009).

Procedures, which are considered more conservative and reliable for measuring effective neutralising capacity above pH 6 are the Lapakko (White et al. 1999) method and the acid buffering characteristic curve (AMIRA 2002) method. The latter test also has the advantage of being indicative of mineralogy. These tests are more time consuming and more costly than the more commonly used tests and thus are not normally run in large quantities. No reference was found to the effect of Fe^{2+} on these tests, although their acidic pH endpoints may result in some acidity not being measured.

If only pyrite contributes acidity and calcite and dolomite contribute significant buffering capacity to a sample, then most procedures should provide reasonably

accurate results, although the fizz test may result in over-estimation of NP if dolomite is the dominant mineral rather than calcite, as dolomite reacts more slowly with acid and is thus likely to result in a lower "fizz rating" for the same concentration of NP. If significant buffering capacity is derived from other carbonates or aluminosilicates, then buffering often occurs below pH 6 (Morin & Hutt 2001, Price 2009, Jambor 2003, Maest & Kuipers 2005), which is too low to ensure compliance with environmentally regulated water quality criteria.

NAG tests are based on sample oxidation by hydrogen peroxide and can be useful additional tests. They cannot be used as standalone tests and must be verified by other data (Price 2009, Morin & Hutt 2001). They provide a mechanism to measure the combined mobilisation of AP from oxidation of sulphides and of NP from easily soluble minerals. The NP can only be measured up to the amount of acidity generated, which is problematic if non stoichiometric consumption of NP is anticipated. NAG tests are considered to be of limited accuracy (although this is inherent in most static tests) and are subject to uncertainty due to potential catalysis of peroxide by metals and interference associated with organic acid generation from carbon-rich samples. They also require sequential extractions for samples containing > 1%S, thus compounding uncertainties. They should thus be used with caution.

Leach tests are used to evaluate samples for their propensity to leach acidity, metals and / or salts. No specific static test is recommended for such purposes at this stage, although multiple extractions are perhaps the most useful generally available option, along with specifically tailored solutions that are adequately justified based on sample composition. The use of distilled water to evaluate contact water pH is useful to test for leachablity of soluble salts and to detect acidity in materials which are already weathered. They are not useful tests for metal leaching potential or acid potential in unoxidised sulphidic mine rock samples.

Besides the abovementioned considerations regarding static tests, different assessment criteria are used to evaluate the results and thus the potential for AMD.

The Net Potential Ratio (NPR) is generally used as the main classification criterion internationally when interpreting ABA results, whereas Net Acid Production Potential (NAPP) is normally used in Australia. NAPP is the difference between AP and NP, compared with the NPR ratio, which is defined as NP / AP. Differences in classification criteria can result in very different classifications. In Figure a plot of selected NPR and NAPP criteria vs Total S (and equivalent pyrite) concentration is provided to illustrate these differences. According to most guidelines, an NPR of >3 (Nevada >1.2 and Price 2009 >2, with several conditions attached) is considered to be safe. According to the NAPP approach (DoITR 2007), an NAPP below 0 is non acid forming (NAF) and below -100 kg H_2SO_4/tonne is acid consuming. NAPP equivalent units of H_2SO_4 differ from $CaCO_3$ by about 2%, so are directly comparable. The use of criteria that require excess NP in a sample are to allow for armouring, differences in kinetics and contact area and non-stoichiometric dissolution (discussed further below).

Figure 1 shows that the NAPP method is very conservative compared with the NPR classification at low sulphide concentrations and falls below the NPR classification criteria when sulphur concentrations increase above 2% to 4%, depending on the criteria used. Assessing such material as "acid consuming" is thus potentially risky. Ultimately chemical reactions are stoichiometric and should thus be evaluated in terms of ratios, rather than differences to avoid such biases.

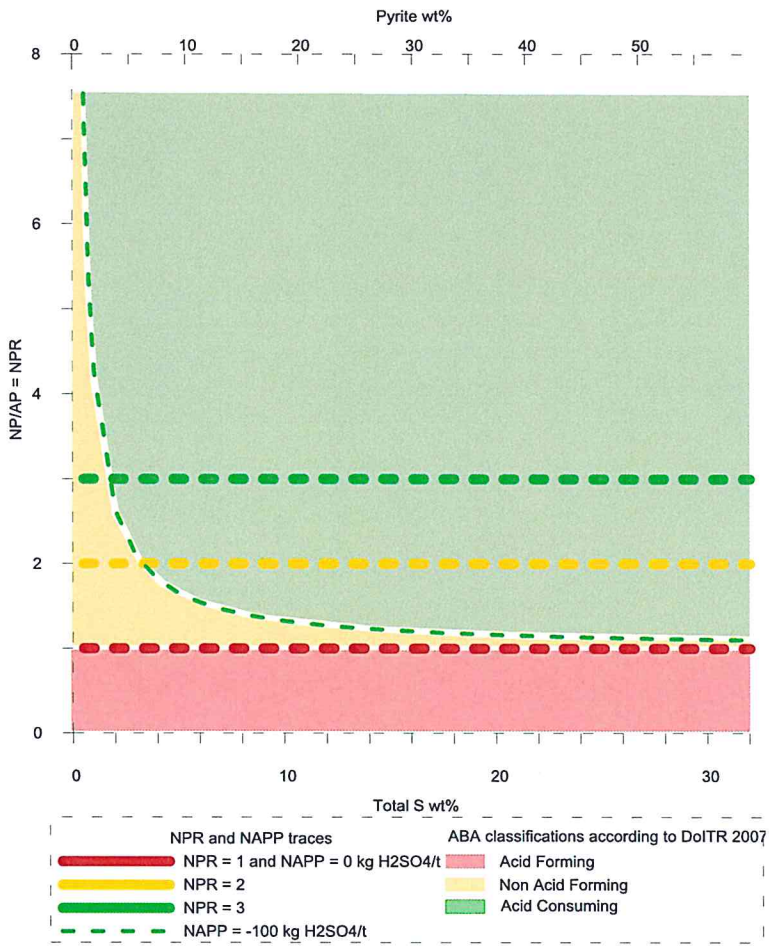

Figure 1 *Comparison of classification criteria using NP/AP ratios (NPR) vs. difference (NAPP or NNP).*

Some influences under field conditions on non-stoichiometric reaction of NP with AP are mentioned in guidelines, although they generally focus on mineral reactions, rather than the physical characteristics of the mine water system. These mineralogical factors include considerations such as occlusion, armouring, differences in mineral reactivity, preferential leaching, solid solution properties, etc.

In open systems, outflowing mine discharge waters, affected by ARD that has reacted with carbonate minerals, can contain high concentrations of mobilised alkalinity (up to several hundred mg/L, with pH commonly >7). This dissolved alkalinity may account for a significant proportion of available alkalinity (theoretically up to 50%), implicit in pH dependent speciation of carbonate between CO_3^{2-}, HCO_3^- and H_2CO_3 (Evangelou, 1998). The fCO_2 is a controlling

variable with respect to carbonate solubility; dissolved alkalinity may therefore be transported at higher concentrations than under atmospheric fCO_2 for solutions in equilibrium with carbonate minerals. This is particularly relevant for confined or semi-confined groundwater systems under pressure, but is also relevant in systems with near atmospheric CO_2 concentrations (e.g. soil profiles).

Additionally, Fe^{2+} is a common constituent of partially oxidised mine waters, in contact with sulphide minerals, even at neutral pH, with the redox potential often controlled by the Fe^{2+}/Fe^{3+} buffer. In open systems that theoretically contain sufficient NP to neutralise acidity that is generated, acidity released through precipitation of Fe-oxyhydroxides after oxidation of Fe^{2+} by atmospheric oxygen may result in a pH <6 downstream, depending on the composition of the effluent. A schematic diagram illustrating some of the interactions between minerals and dissolved species in a pyrite-calcite driven system is included in Figure . Some aspects of open system behaviour are shown, with solutes being transported away from their site of origin.

Along with the bulk system properties that may influence the acid-base balance in open systems, aspects such as flow paths and material location can play an important role in preferential leaching of alkalinity or acidity. In high recharge environments rainfall may also leach a significant amount of available alkalinity from a waste profile, depending on mineral solubility, flow dynamics and the composition of rainwater.

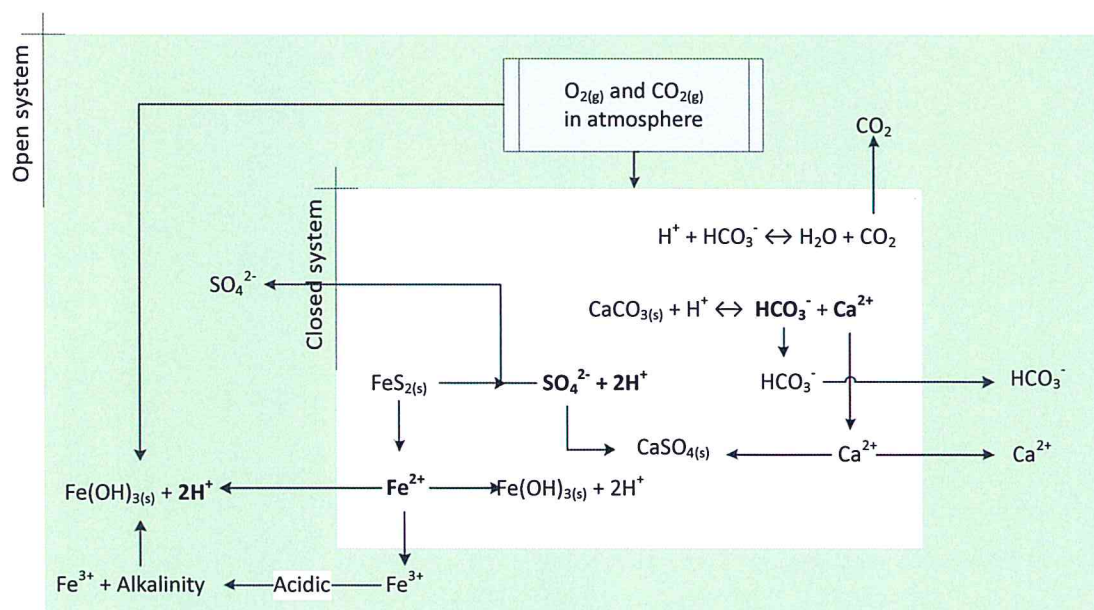

Figure 2 *A simplified schematic diagram illustrating the evolution of a pyrite-calcite reaction, showing closed system and open system aspects.*

Conclusions

Static geochemical test methods generally only provide approximate results, the accuracy of which is strongly influenced by mineralogy. It is important to be aware of these uncertainties when using these methods, as erroneous conclusions can easily be reached by following guideline "criteria" without verifying the results.

Discrepancies between classification criteria, e.g. using NPR vs NAPP, can also lead to very different classifications, depending on the sulphur content of the sample. The NAPP system, although based on empirical laboratory data, should perhaps be reviewed on the basis that it penalises waste materials containing low sulphur concentrations excessively and provides excessive confidence in the neutralising capacity of high sulphur samples.

The representativeness of test data must be verified for each rock type and each test before it is, considered as definitive. This observation is particularly relevant when developing material management strategies based on geological block model total elemental geochemistry data. Since elemental abundance does not necessarily correlate with a single mineral, and thus reactivity and leaching potential, major miscalculations can be made if geochemical test data are not evaluated correctly or inappropriate tests are used for "calibration".

In addition to uncertainties associated with static test methods, the context of the project environment should be considered when interpreting static test data and should bear in mind that open systems may behave differently to closed systems represented by static test results. This is particularly important for "flow-through" sites where carbonate minerals react with AMD, with subsequent loss of alkalinity that may otherwise prevent acidification if it were retained within the system.

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Appendix C : NRCS Custom Soils Report for Potential Land Application Discharge Area

Appendix C

NRCS Custom Soil Resource Report for Gallatin National Forest Area, Montana

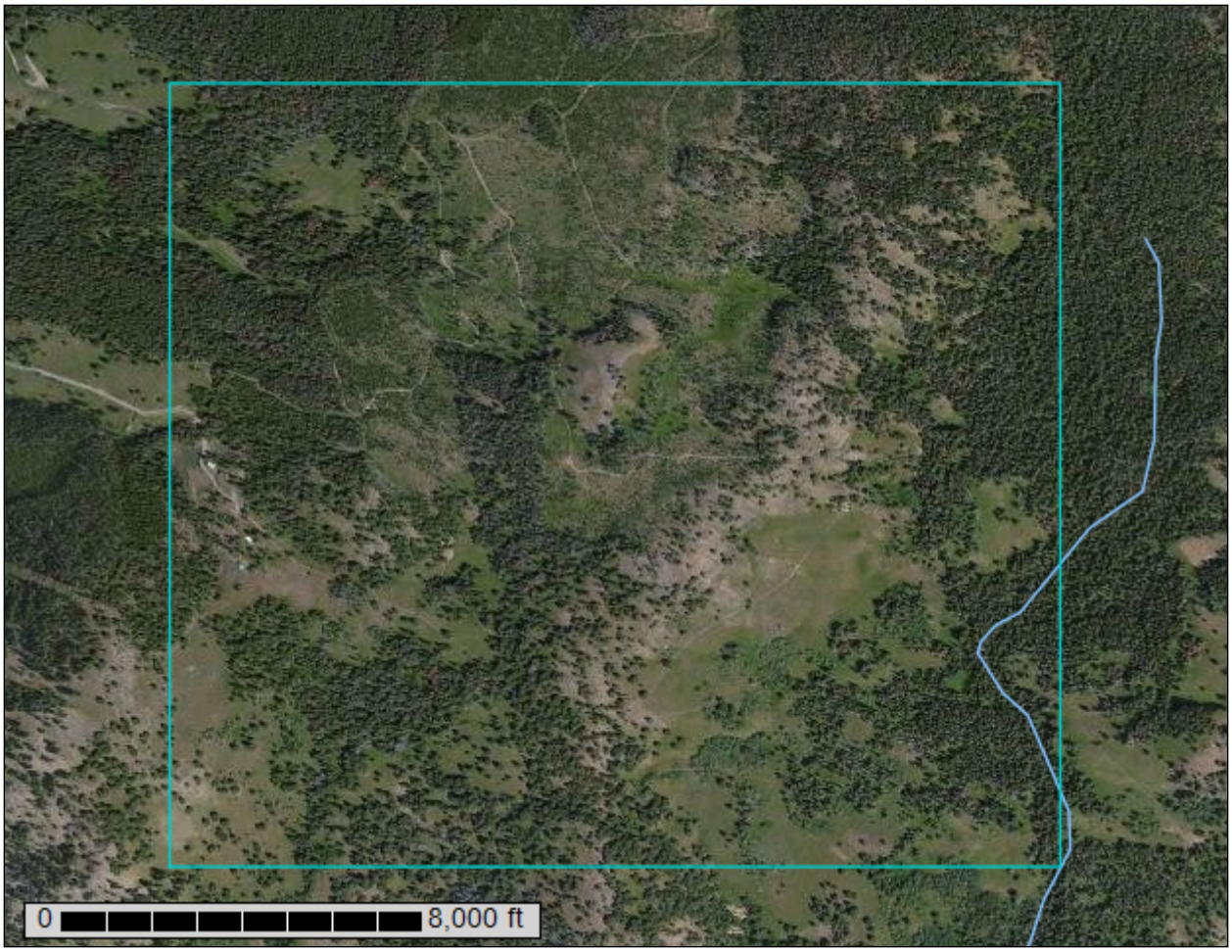
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Gallatin National Forest Area, Montana



July 14, 2015

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

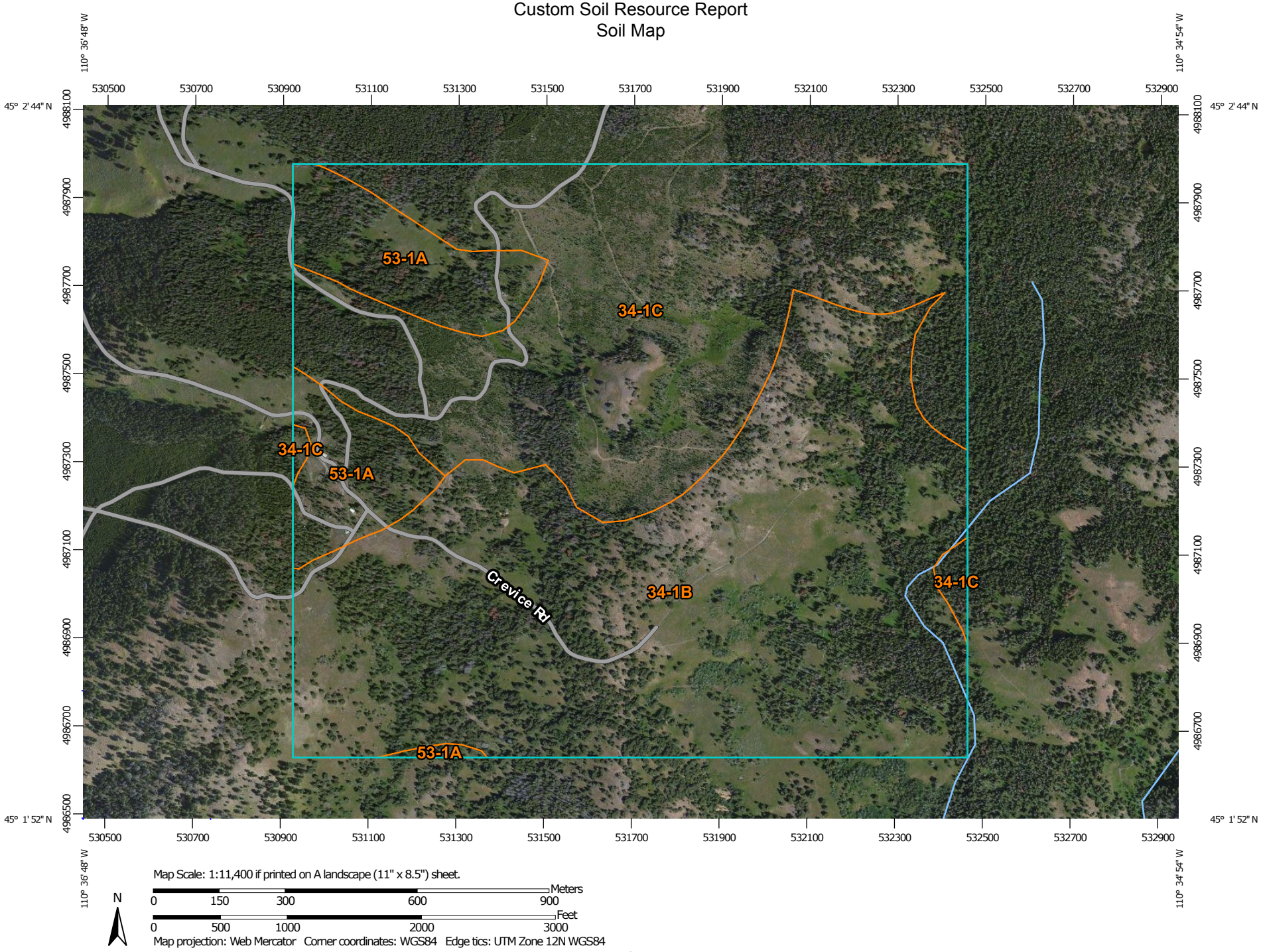
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin National Forest Area, Montana
Survey Area Data: Version 6, Sep 3, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 17, 2011—Aug 19, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Gallatin National Forest Area, Montana (MT623)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	262.6	51.1%
34-1C	Typic Cryochrepts, glacial drift substratum	199.8	38.9%
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	51.8	10.1%
Totals for Area of Interest		**514.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic

classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Gallatin National Forest Area, Montana

34-1B—Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum

Map Unit Setting

National map unit symbol: 58js
Elevation: 6,500 to 7,500 feet
Mean annual precipitation: 20 to 35 inches
Mean annual air temperature: 36 to 43 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Argic cryoborolls and similar soils: 50 percent
Typic cryoborolls and similar soils: 45 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Argic Cryoborolls

Setting

Landform: Moraines
Parent material: Glacial drift derived from granite

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: Douglas-fir/Idaho fescue (PK220)

Description of Typic Cryoborolls

Setting

Landform: Moraines
Parent material: Loamy glacial drift derived from granite

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: Douglas-fir/Idaho fescue (PK220)

Minor Components

Rock outcrop

Percent of map unit: 5 percent

34-1C—Typic Cryochrepts, glacial drift substratum

Map Unit Setting

National map unit symbol: 58jt
Elevation: 6,700 to 7,900 feet
Mean annual precipitation: 50 to 60 inches
Mean annual air temperature: 36 to 39 degrees F
Frost-free period: 30 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Typic cryochrepts and similar soils: 75 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Typic Cryochrepts

Setting

Landform: Moraines
Parent material: Glacial drift derived from granite

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Other vegetative classification: subalpine fir/grouse whortleberry (PK730)

Minor Components

Rock outcrop

Percent of map unit: 10 percent
Other vegetative classification: subalpine fir/grouse whortleberry (PK730)

53-1A—Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect

Map Unit Setting

National map unit symbol: 58kd
Elevation: 6,800 to 7,800 feet
Mean annual precipitation: 20 to 35 inches
Mean annual air temperature: 36 to 43 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Typic cryoborolls and similar soils: 50 percent
Argic cryoborolls and similar soils: 25 percent
Rock outcrop: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Typic Cryoborolls

Setting

Landform: Hills
Parent material: Loamy colluvium derived from granite

Properties and qualities

Slope: 10 to 45 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: Douglas-fir/snowberry (PK310)

Description of Argic Cryoborolls

Setting

Landform: Hills
Parent material: Loamy colluvium derived from granite

Properties and qualities

Slope: 10 to 45 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: Douglas-fir/snowberry (PK310)

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Construction Materials

Construction materials interpretations are tools designed to provide guidance to users in selecting a site for potential source of various materials. Individual soils or groups of soils may be selected as a potential source because they are close at hand, are the only source available, or they meets some or all of the physical or chemical properties required for the intended application. Example interpretations include roadfill, sand and gravel, topsoil and reclamation material.

Source of Reclamation Material

Reclamation material is used in areas that have been drastically disturbed by surface mining or similar activities. When these areas are reclaimed, layers of soil material or unconsolidated geological material, or both, are replaced in a vertical sequence. The reconstructed soil favors plant growth. The ratings do not apply to quarries or other mined areas that require an offsite source of reconstruction material. The ratings are based on the soil properties that affect erosion and stability of the surface and the productive potential of the reclaimed soil. These properties include the content of sodium, salts, and calcium carbonate; reaction; available water capacity; erodibility; texture; content of rock fragments; and content of organic matter and other features that affect fertility.

The soils are rated "good," "fair," or "poor" as potential sources of reclamation material. The ratings are based on the amount of suitable material and on soil properties that affect the ease of excavation and the performance of the material after it is in place. The thickness of the suitable material is a major consideration. The ease of excavation is affected by large stones, depth to a water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the AASHTO classification of the soil) and linear extensibility

(shrink-swell potential). Normal compaction, minor processing, and other standard construction practices are assumed.

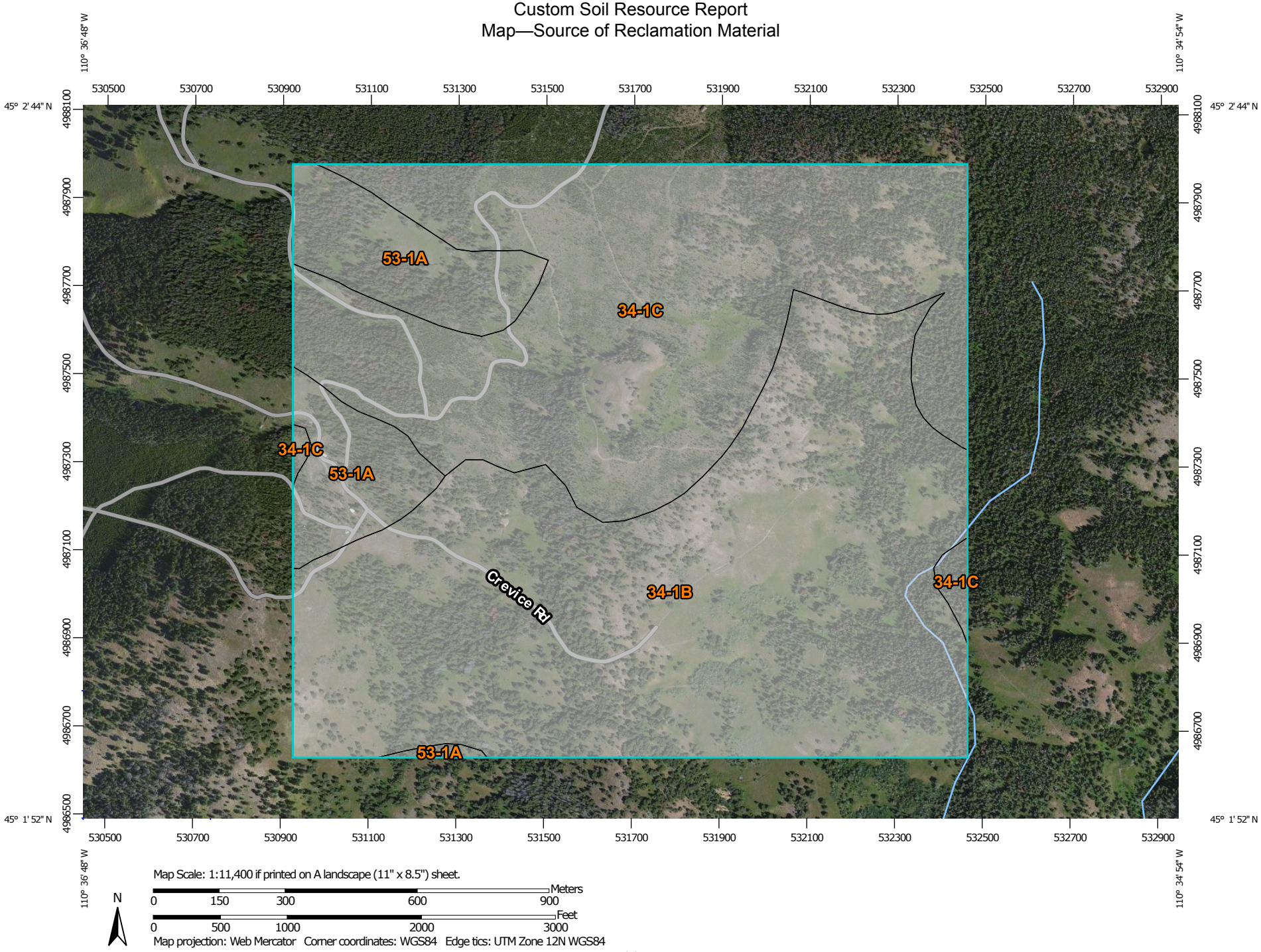
When the material is properly used in reclamation, a rating of "good" means that establishing and maintaining vegetation are relatively easy, that the surface is stable and resists erosion, and that the reclaimed soil has good potential productivity. A rating of "fair" means that vegetation can be established and maintained and the soil can be stabilized through modification of one or more properties. For satisfactory performance, it may be necessary to topdress with better suited material or add soil amendments. A rating of "poor" means that revegetation and stabilization are very difficult and costly. To establish and maintain vegetation, it is necessary to topdress with better suited material.

Numerical ratings between 0.00 and 0.99 are given after the specified features. These numbers indicate the degree to which the features limit the soils as sources of reclamation material. The lower the number, the greater the limitation.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Source of Reclamation Material



Map Scale: 1:11,400 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Poor

Fair

Good

Not rated or not available

Soil Rating Lines

Poor

Fair

Good

Not rated or not available

Soil Rating Points

Poor

Fair

Good

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin National Forest Area, Montana
Survey Area Data: Version 6, Sep 3, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 17, 2011—Aug 19, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Source of Reclamation Material

Source of Reclamation Material— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not rated	Argic Cryoborolls (50%)		262.6	51.1%
			Typic Cryoborolls (45%)			
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Not rated	Typic Cryochrepts (75%)		199.8	38.9%
			Rock outcrop (10%)			
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Not rated	Typic Cryoborolls (50%)		51.8	10.1%
			Argic Cryoborolls (25%)			
			Rock outcrop (15%)			
Totals for Area of Interest					**514.2**	**100.0%**

Source of Reclamation Material— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Null or Not Rated	514.2	100.0%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Source of Reclamation Material

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Topsoil Source

Topsoil is used to cover an area so that vegetation can be established and maintained. The surface layer of most soils is generally preferred for topsoil because of its content of organic matter. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area. Normal compaction, minor processing, and other standard construction practices are assumed.

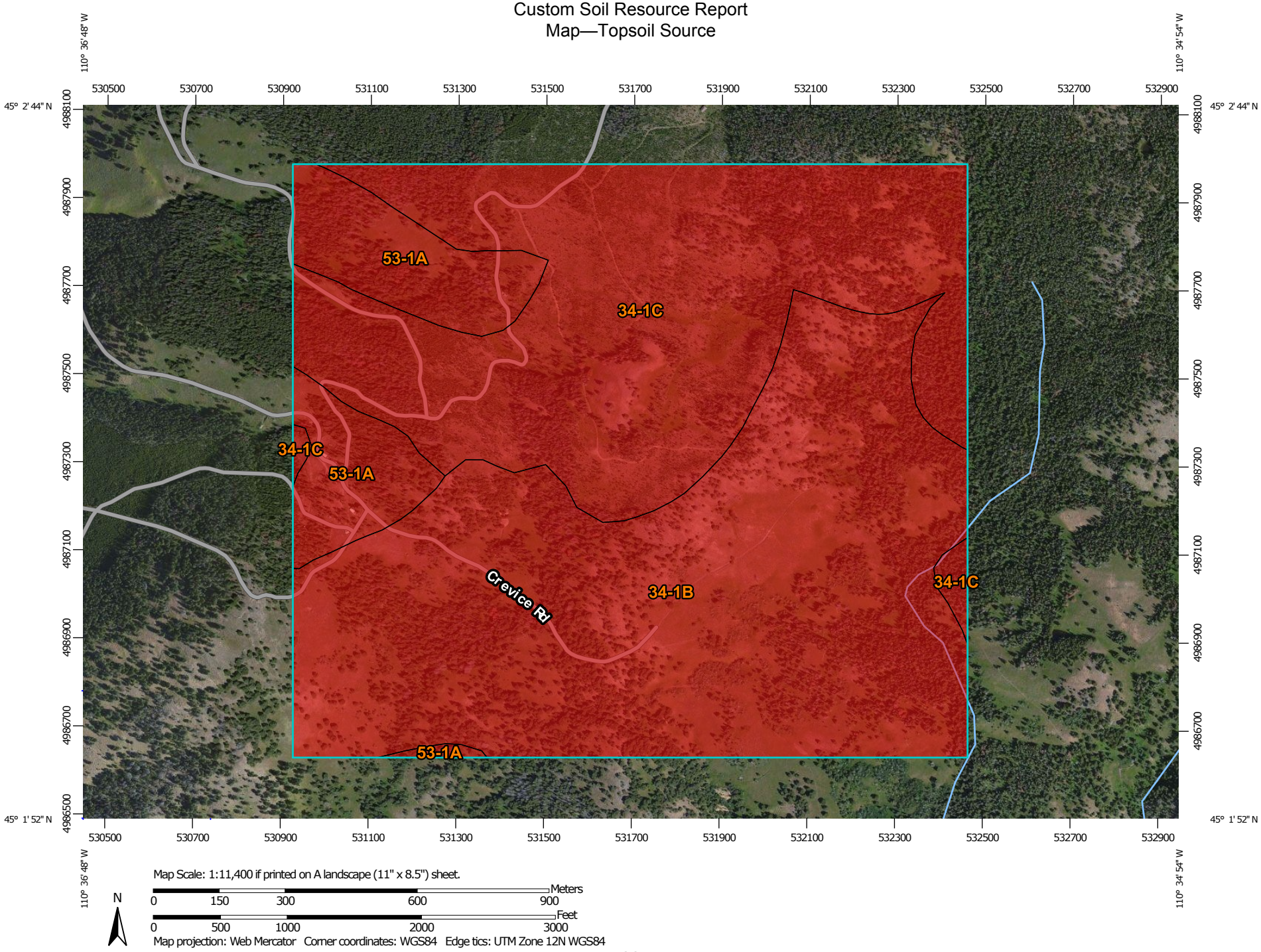
The soils are rated "good," "fair," or "poor" as potential sources of topsoil. The ratings are based on the soil properties that affect plant growth; the ease of excavating, loading, and spreading the material; and reclamation of the borrow area. Toxic substances, soil reaction, and the properties that are inferred from soil texture, such as available water capacity and fertility, affect plant growth. The ease of excavating, loading, and spreading is affected by rock fragments, slope, depth to a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, depth to a water table, rock fragments, depth to bedrock or a cemented pan, and toxic material.

Numerical ratings between 0.00 and 0.99 are given after the specified features. These numbers indicate the degree to which the features limit the soils as sources of topsoil. The lower the number, the greater the limitation.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Topsoil Source



Map Scale: 1:11,400 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Poor

Fair

Good

Not rated or not available

Soil Rating Lines

Poor

Fair

Good

Not rated or not available

Soil Rating Points

Poor

Fair

Good

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin National Forest Area, Montana
Survey Area Data: Version 6, Sep 3, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 17, 2011—Aug 19, 2011

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Tables—Topsoil Source

Topsoil Source— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Poor	Argic Cryoborolls (50%)	Rock fragments (0.00)	262.6	51.1%
				Hard to reclaim (rock fragments) (0.00)		
				Slope (0.37)		
				Exchange capacity (0.89)		
			Typic Cryoborolls (45%)	Rock fragments (0.00)		
				Hard to reclaim (rock fragments) (0.00)		
				Slope (0.37)		
				Exchange capacity (0.78)		
34-1C	Typic Cryochrepts, glacial drift substratum	Poor	Typic Cryochrepts (75%)	Hard to reclaim (rock fragments) (0.00)	199.8	38.9%
				Rock fragments (0.00)		
				Slope (0.37)		
				Exchange capacity (0.81)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Poor	Typic Cryoborolls (50%)	Rock fragments (0.00)	51.8	10.1%
				Hard to reclaim (rock fragments) (0.00)		
				Slope (0.00)		
				Exchange capacity (0.78)		
			Argic Cryoborolls (25%)	Rock fragments (0.00)		
				Hard to reclaim (rock fragments) (0.00)		
				Slope (0.00)		

Topsoil Source— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
				Exchange capacity (0.91)		
Totals for Area of Interest					**514.2**	**100.0%**

Topsoil Source— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Poor	514.2	100.0%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Topsoil Source

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Hydric Rating by Map Unit

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

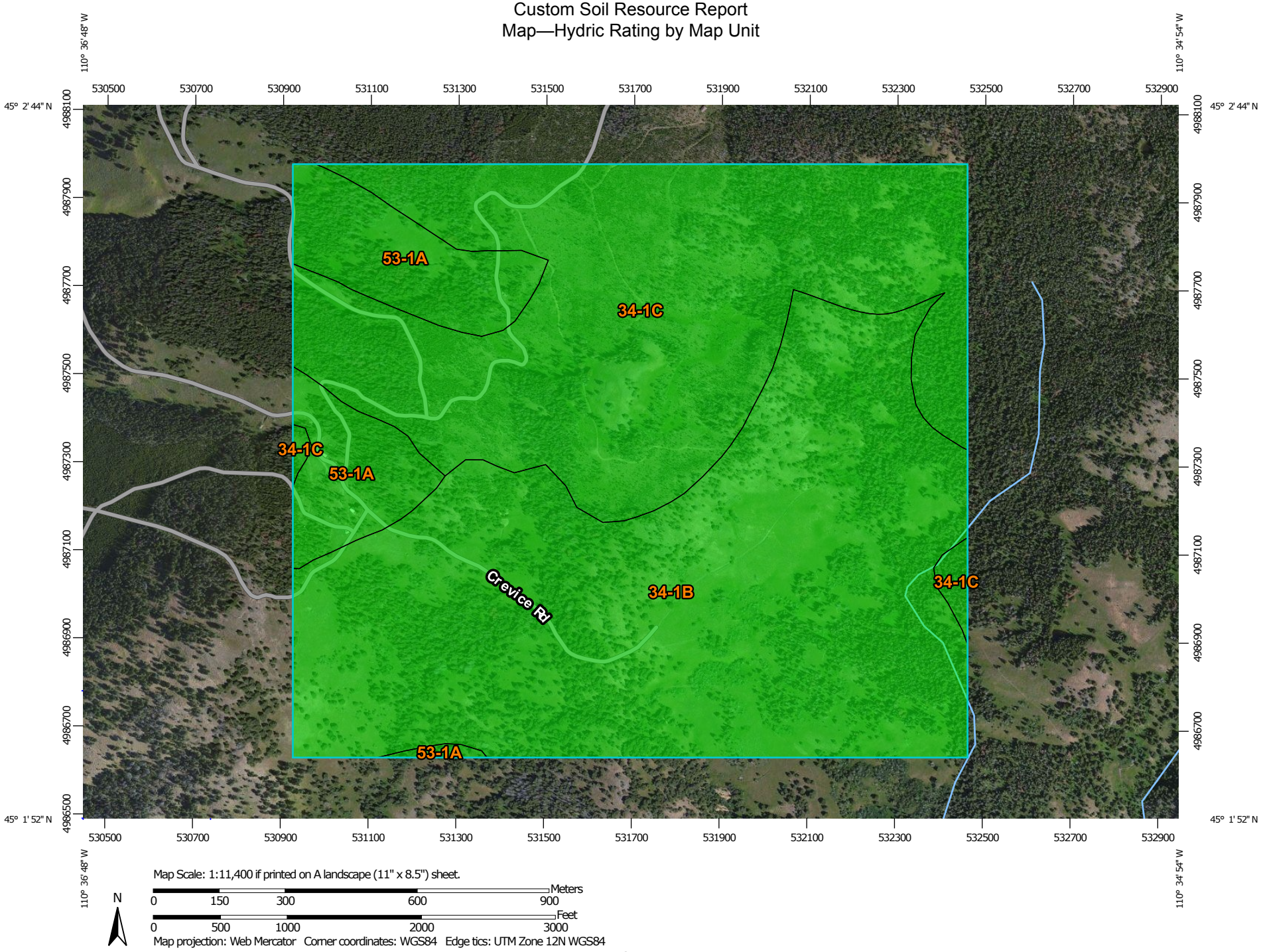
Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Custom Soil Resource Report
Map—Hydric Rating by Map Unit



Map Scale: 1:11,400 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Hydric (100%)

Hydric (66 to 99%)

Hydric (33 to 65%)

Hydric (1 to 32%)

Not Hydric (0%)

Not rated or not available

Soil Rating Lines

Hydric (100%)

Hydric (66 to 99%)

Hydric (33 to 65%)

Hydric (1 to 32%)

Not Hydric (0%)

Not rated or not available

Soil Rating Points

Hydric (100%)

Hydric (66 to 99%)

Hydric (33 to 65%)

Hydric (1 to 32%)

Not Hydric (0%)

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Table—Hydric Rating by Map Unit

Hydric Rating by Map Unit— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	0	262.6	51.1%
34-1C	Typic Cryochrepts, glacial drift substratum	0	199.8	38.9%
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	0	51.8	10.1%
Totals for Area of Interest			**514.2**	**100.0%**

Rating Options—Hydric Rating by Map Unit

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Water Management

Water Management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Irrigation, Surface (Level)

This interpretation evaluates a soil's limitation(s) for basin, paddy, level furrow, or level border irrigation systems. The ratings are for soils in their natural condition and do not consider present land use.

Level surface irrigation systems use flood irrigation techniques to spread irrigation water at a specified depth across the application area. Basin, paddy, and borders generally use external ridges or borders to confine the water, while level furrow systems use furrow valleys and end blocks or border ridges to confine the water during irrigation. With furrow irrigation the crop is usually planted on the furrow ridge. Generally, basin, paddy and level border irrigation systems are suitable for rice, small grain, pasture, and forage production. Level furrow systems are generally suited for row crops.

The soil properties and qualities important in the design and management of level surface irrigation systems are depth, available water holding capacity, sodium adsorption ratio, saturated hydraulic conductivity, salinity, slope, and flooding. The soil

properties and qualities that influence installation are depth, flooding, and ponding. The features that affect performance of the system and plant growth are salinity, sodium adsorption ratio, and available water holding capacity.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms indicate the extent to which the soils are limited by the soil features that affect the soil interpretation. Verbal soil rating classes are based on the highest numerical rating for the most limiting soil feature(s) considered in the rating process. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has no limiting features for the specified use. "Somewhat limited" (numerical value for the most restrictive feature =.01 to .99) indicates that the soil has limiting features for the specified use that can be overcome with proper planning, design, installation, and management. The effort required to overcome a soil limitation increases as the numerical rating increases. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more very limiting features that can only be overcome with special planning, major soil modification, special design, or significant management practices.

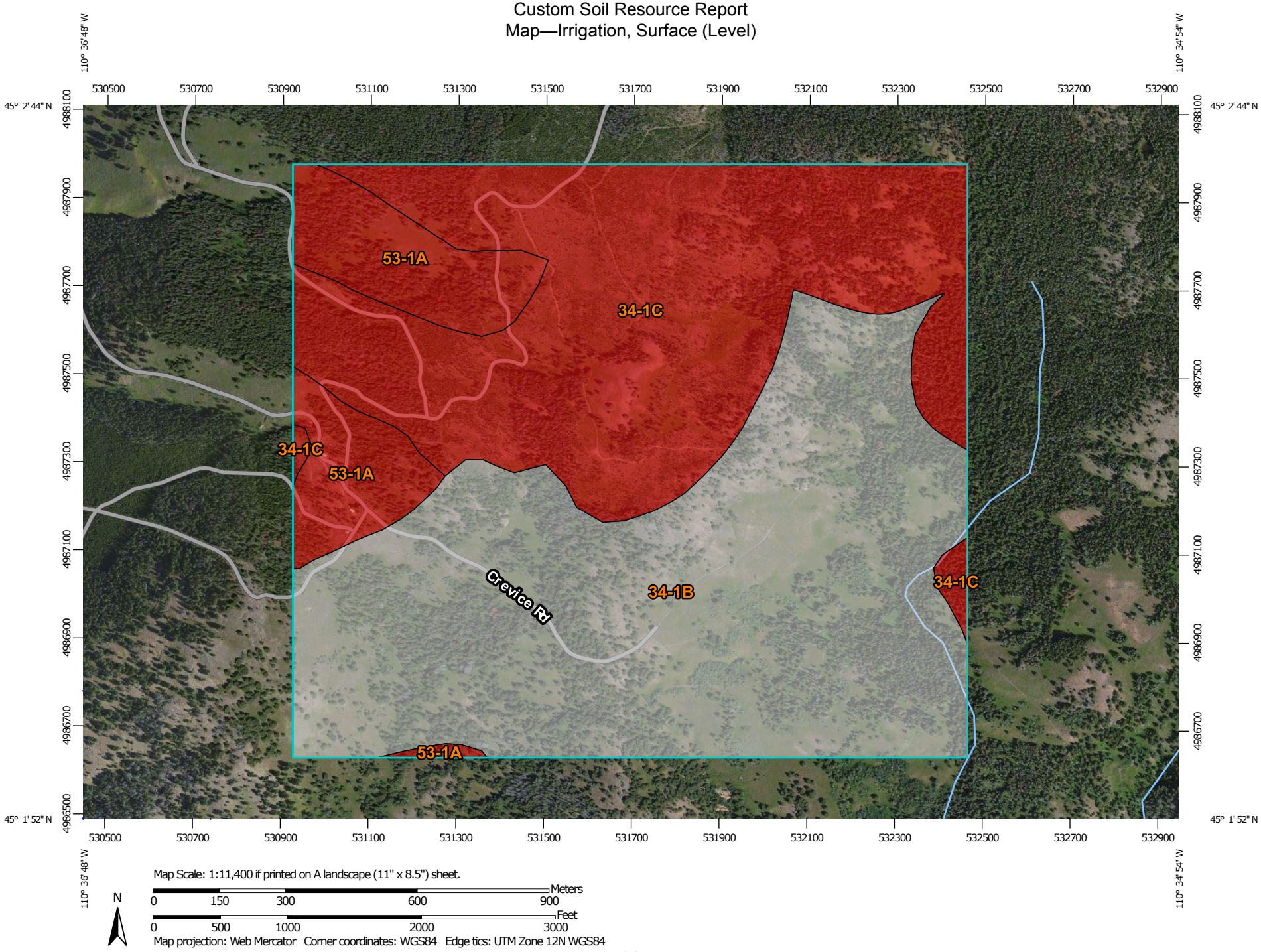
Lesser soil restrictive features have a lower numerical value than the maximum used to rate the soil, and they are identified to provide the user with additional information about soil limitations for the specific use. Lesser soil restrictive features also need to be considered in planning, design, installation, and management.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Irrigation, Surface (Level)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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Tables—Irrigation, Surface (Level)

Irrigation, Surface (Level)— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not Rated	Argic Cryoborolls (50%)		262.6	51.1%
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Very limited	Typic Cryochrepts (75%)	Slope (1.00)	199.8	38.9%
				Content of large stones (1.00)		
				Rapid water movement (0.69)		
				Low water holding capacity (0.68)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Very limited	Typic Cryoborolls (50%)	Slope (1.00)	51.8	10.1%
				Seepage (1.00)		
				Rapid water movement (0.69)		
				Low water holding capacity (0.67)		
Totals for Area of Interest					**514.2**	**100.0%**

Irrigation, Surface (Level)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not Rated	262.6	51.1%
Very limited	251.6	48.9%
Null or Not Rated	262.6	51.1%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Irrigation, Surface (Level)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Irrigation, Sprinkler (General)

This interpretation evaluates a soil's limitation(s) for installation and use of sprinkler irrigation systems, excluding those equipped with closely spaced outlets on drops,

which are covered by a different interpretation. The ratings are for soils in their natural condition and do not consider present land use.

Sprinkler irrigation systems apply irrigation water to a field through a series of pipes and nozzles and can be either solid set or mobile. Generally, this type of irrigation system is suitable for small grains, row crops, vegetables, and orchards.

The soil properties and qualities important in the design and management of sprinkler irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, saturated hydraulic conductivity, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface rocks, salinity, sodium adsorption ratio, wetness, and available water holding capacity.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms indicate the extent to which the soils are limited by the soil features that affect the soil interpretation. Verbal soil rating classes are based on the highest numerical rating for the most limiting soil feature(s) considered in the rating process. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has no limiting features for the specified use. "Somewhat limited" (numerical value for the most restrictive feature =.01 to .99) indicates that the soil has limiting features for the specified use that can be overcome with proper planning, design, installation, and management. The effort required to overcome a soil limitation increases as the numerical rating increases. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more very limiting features that can only be overcome with special planning, major soil modification, special design, or significant management practices.

Lesser soil restrictive features have a lower numerical value than the maximum used to rate the soil, and they are identified to provide the user with additional information about soil limitations for the specific use. Lesser soil restrictive features also need to be considered in planning, design, installation, and management.

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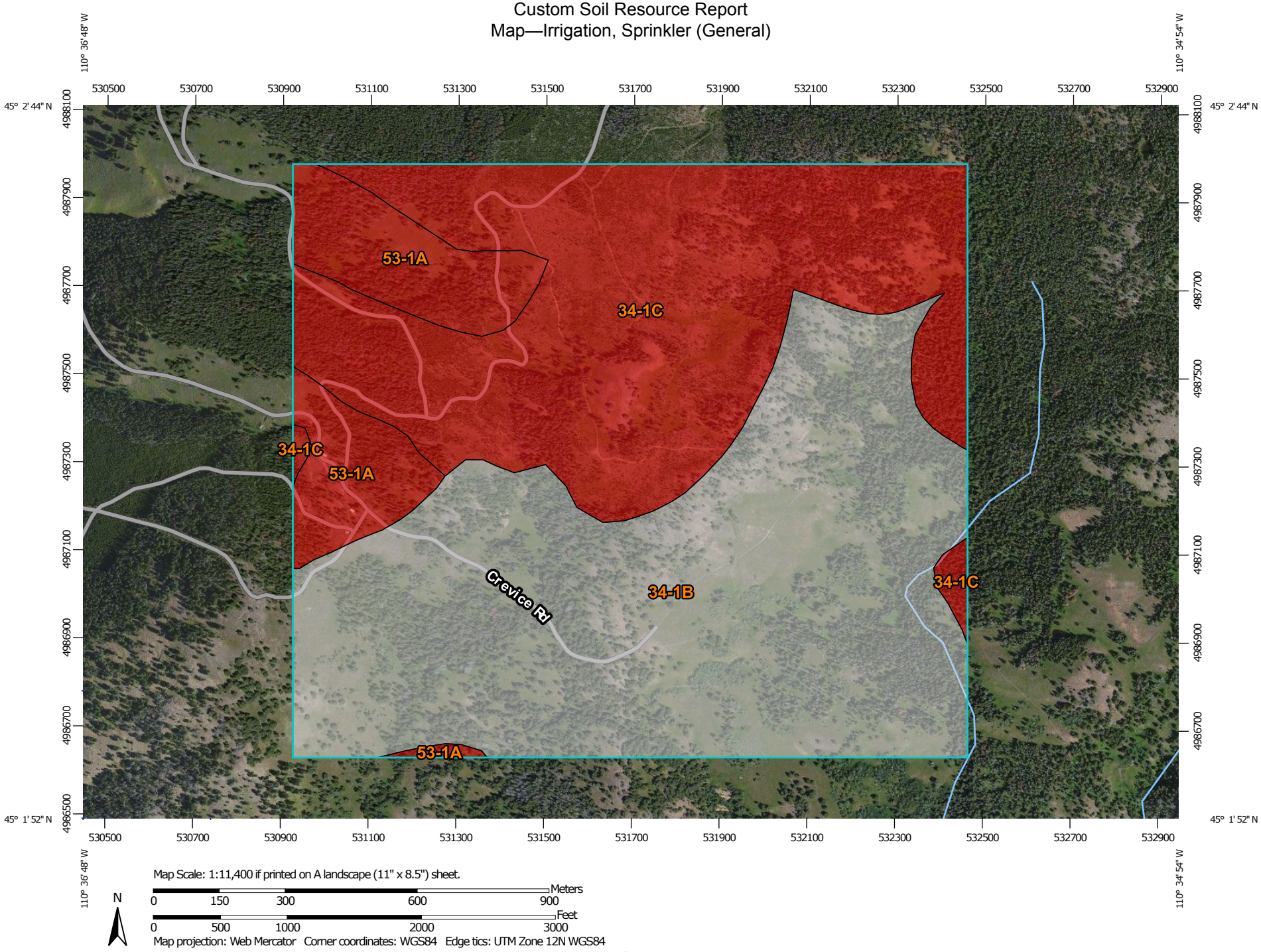
The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Irrigation, Sprinkler (General)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin National Forest Area, Montana
Survey Area Data: Version 6, Sep 3, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 17, 2011—Aug 19, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Irrigation, Sprinkler (General)

Irrigation, Sprinkler (General)— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not Rated	Argic Cryoborolls (50%)		262.6	51.1%
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Very limited	Typic Cryochrepts (75%)	Content of large stones (1.00)	199.8	38.9%
				Slope, sprinkler irrigation (0.78)		
				Low water holding capacity (0.58)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Very limited	Typic Cryoborolls (50%)	Slope, sprinkler irrigation (1.00)	51.8	10.1%
				Low water holding capacity (0.57)		
Totals for Area of Interest					**514.2**	**100.0%**

Irrigation, Sprinkler (General)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not Rated	262.6	51.1%
Very limited	251.6	48.9%
Null or Not Rated	262.6	51.1%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Irrigation, Sprinkler (General)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Subsurface Water Management, Outflow Quality

The ratings for Subsurface Water Management, Outflow Quality are based on the soil properties that affect the capacity of the soil to convey surface and subsurface water and on the properties that affect water quality. The properties that affect the conveyance and water quality include salinity, sodicity, soil reaction, soil taxonomic great group placement, gypsum content, shrink-swell potential, soil saturation, and surface erosion.

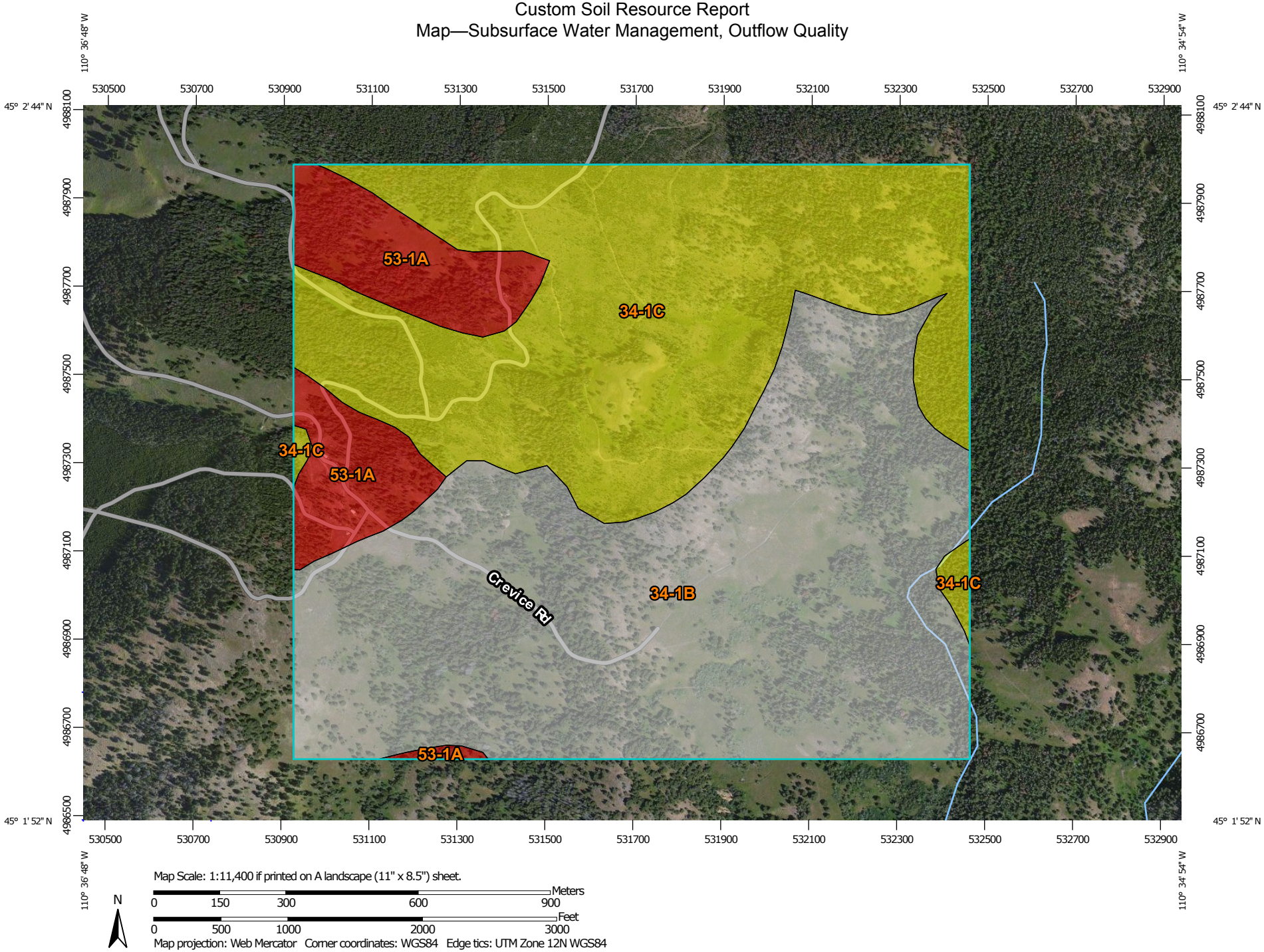
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor water quality can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as that listed for the map unit. The percent composition of each component in a particular map unit is given so that the user will realize the percentage of each map unit that has the specified rating.

A map unit may have other components with different ratings. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Subsurface Water Management, Outflow Quality



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Tables—Subsurface Water Management, Outflow Quality

Subsurface Water Management, Outflow Quality— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not Rated	Argic Cryoborolls (50%)		262.6	51.1%
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Somewhat limited	Typic Cryochrepts (75%)	Water Erosion (0.54)	199.8	38.9%
				Pesticide and nutrient movement (0.22)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Very limited	Typic Cryoborolls (50%)	Water Erosion (1.00)	51.8	10.1%
				Pesticide and nutrient movement (0.22)		
Totals for Area of Interest					**514.2**	**100.0%**

Subsurface Water Management, Outflow Quality— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not Rated	262.6	51.1%
Somewhat limited	199.8	38.9%
Very limited	51.8	10.1%
Null or Not Rated	262.6	51.1%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Subsurface Water Management, Outflow Quality

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Surface Water Management, System

The ratings for Surface Water Management, System are based on the soil properties that affect the capacity of the soil to convey surface water across the landscape. Factors affecting the system installation and performance are considered. Water conveyances include graded ditches, grassed waterways, terraces, and diversions. The ratings are for soils in their natural condition and do not consider present land use. The properties that affect the surface system performance include depth to

bedrock, saturated hydraulic conductivity, depth to cemented pan, slope, flooding, ponding, large stone content, sodicity, surface water erosion, and gypsum content.

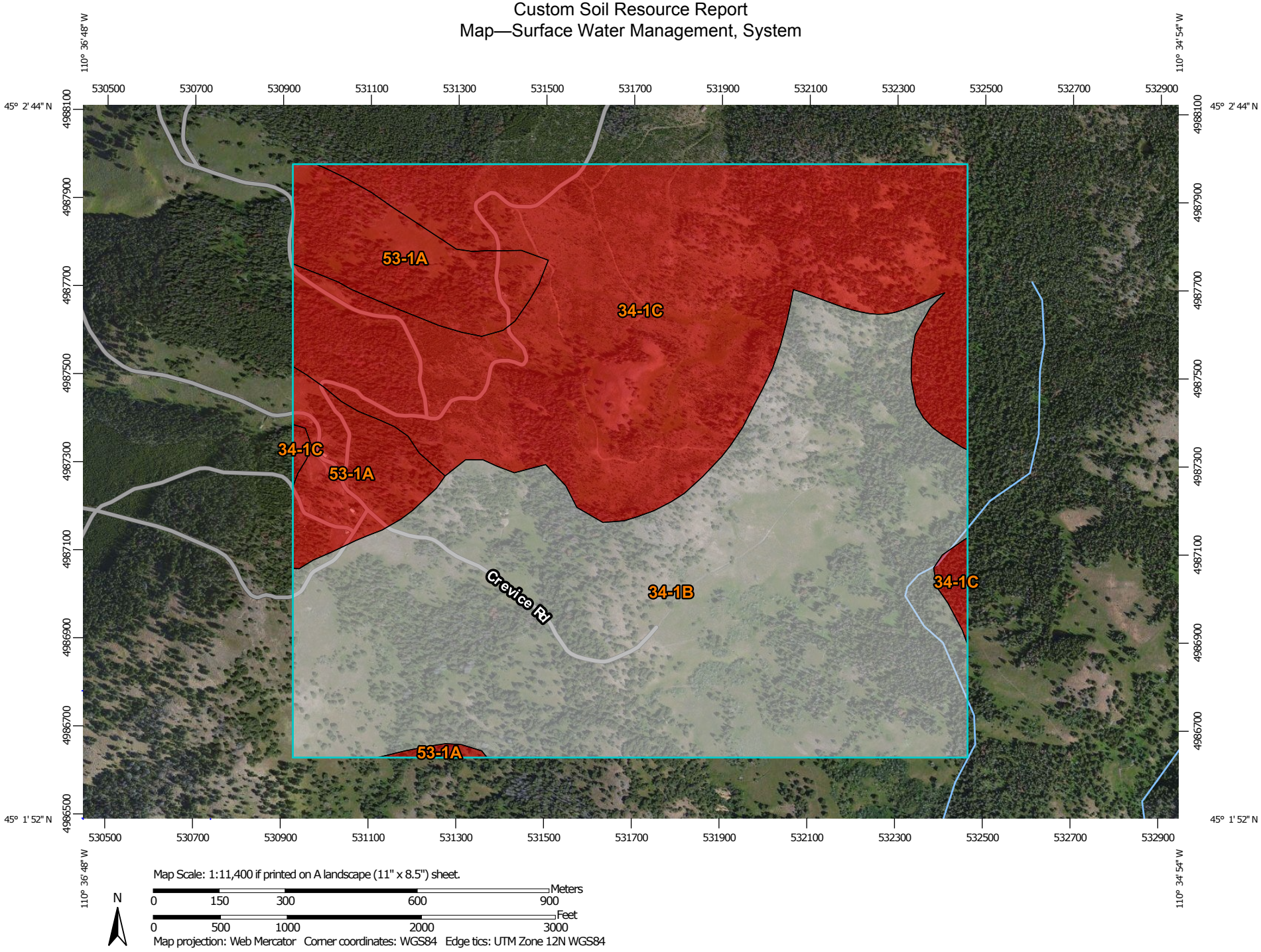
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as that listed for the map unit. The percent composition of each component in a particular map unit is given so that the user will realize the percentage of each map unit that has the specified rating.

A map unit may have other components with different ratings. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Surface Water Management, System



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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Tables—Surface Water Management, System

Surface Water Management, System— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not Rated	Argic Cryoborolls (50%)		262.6	51.1%
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Very limited	Typic Cryochrepts (75%)	Large rock fragments (1.00)	199.8	38.9%
				Slope (1.00)		
				Water Erosion (0.54)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Very limited	Typic Cryoborolls (50%)	Slope (1.00)	51.8	10.1%
				Water Erosion (1.00)		
				Large rock fragments (1.00)		
Totals for Area of Interest					**514.2**	**100.0%**

Surface Water Management, System— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Not Rated	262.6	51.1%
Very limited	251.6	48.9%
Null or Not Rated	262.6	51.1%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Surface Water Management, System

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Irrigation, General

This interpretation evaluates a soil's limitation(s) for installation and use of irrigation systems. This interpretation is for non-specific irrigation methods and is intended to provide initial planning information. If the type of irrigation system has been determined, additional interpretations provide more specific information. This interpretation does not apply if the crop planned for irrigation is rice or other crops (such as cranberries) with unique plant physiological characteristics. The ratings are for soils in their natural condition and do not consider present land use.

Irrigation systems are used to provide supplemental water to crops, orchards, vineyards, and vegetables in areas where natural precipitation will not support desired production of crops being grown.

The soil properties and qualities important in design and management of irrigation systems are sodium adsorption ratio, depth to high water table, available water holding capacity, saturated hydraulic conductivity (Ksat), slope, calcium carbonate content, ponding, and flooding. Soil properties and qualities that influence installation are stones, depth to bedrock or cemented pan, and depth to a high water table. The properties and qualities that affect performance of the irrigation system are depth to bedrock or to a cemented pan, the sodium adsorption ratio, salinity, and soil reaction.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms indicate the extent to which the soils are limited by the soil features that affect the soil interpretation. Verbal soil rating classes are based on the highest numerical rating for the most limiting soil feature(s) considered in the rating process. "Not limited" (numerical value for the most restrictive feature = 0.00) indicates that the soil has no limiting features for the specified use. "Somewhat limited" (numerical value for the most restrictive feature =.01 to .99) indicates that the soil has limiting features for the specified use that can be overcome with proper planning, design, installation, and management. The effort required to overcome a soil limitation increases as the numerical rating increases. "Very limited" (numerical value for the most restrictive feature = 1.00) indicates that the soil has one or more very limiting features that can only be overcome with special planning, major soil modification, special design, or significant management practices.

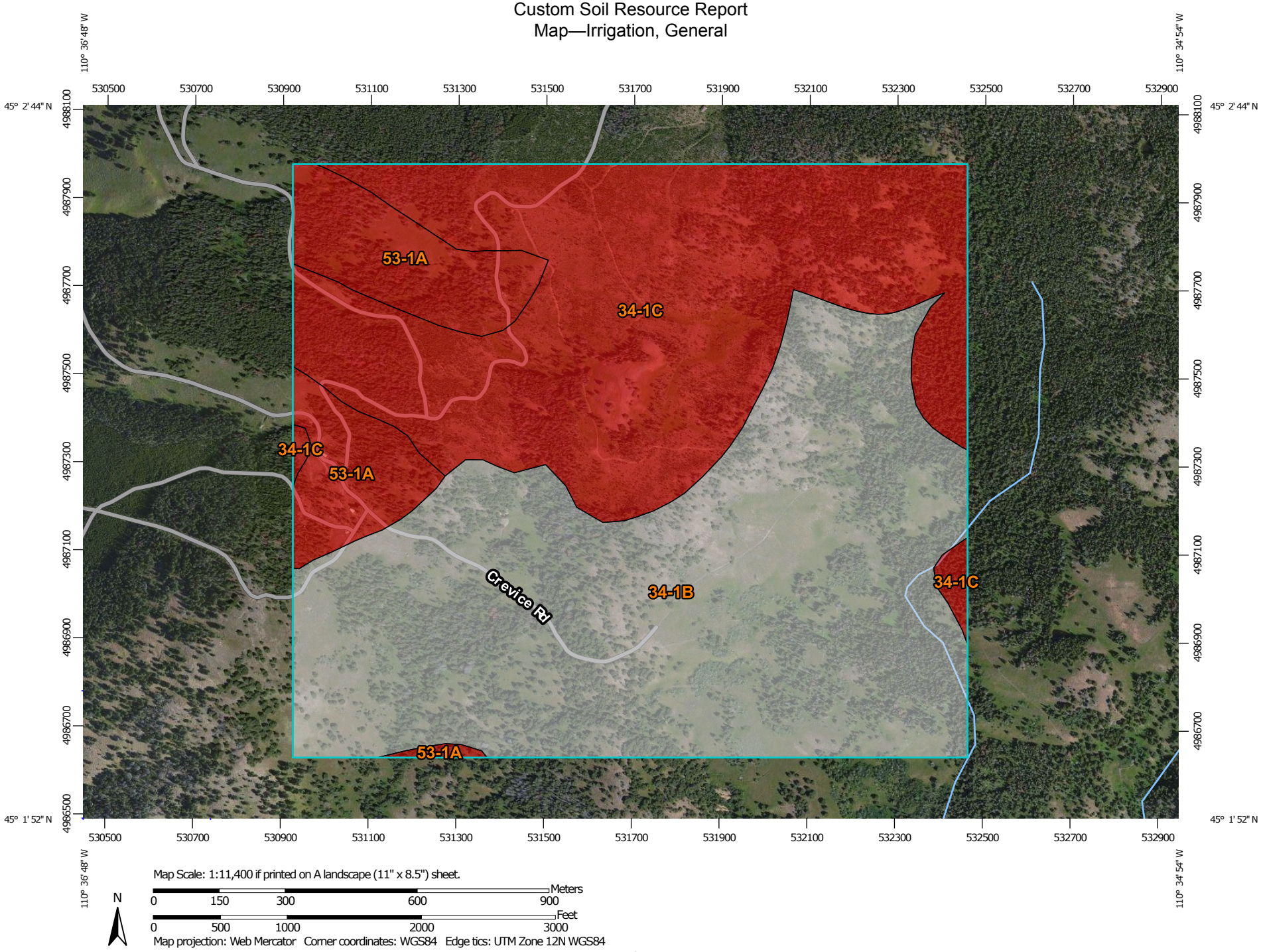
Lesser soil restrictive features have a lower numerical value than the maximum used to rate the soil, and they are identified to provide the user with additional information about soil limitations for the specific use. Lesser soil restrictive features also need to be considered in planning, design, installation, and management.

The results of this interpretation are not designed or intended to be used in a regulatory manner.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Irrigation, General



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Please rely on the bar scale on each map sheet for map measurements.

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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Tables—Irrigation, General

Irrigation, General— Summary by Map Unit — Gallatin National Forest Area, Montana (MT623)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
34-1B	Argic Cryoborolls and Typic Cryoborolls, glacial drift substratum	Not rated	Argic Cryoborolls (50%)		262.6	51.1%
			Rock outcrop (5%)			
34-1C	Typic Cryochrepts, glacial drift substratum	Very limited	Typic Cryochrepts (75%)	Content of large stones (1.00)	199.8	38.9%
				Slope (0.91)		
				Rapid water movement (0.69)		
				Low water holding capacity (0.68)		
53-1A	Typic Cryoborolls-Argic Cryoborolls-Rock outcrop association, south aspect	Very limited	Typic Cryoborolls (50%)	Seepage (1.00)	51.8	10.1%
				Slope (1.00)		
				Rapid water movement (0.69)		
				Low water holding capacity (0.67)		
Totals for Area of Interest					**514.2**	**100.0%**

Irrigation, General— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	251.6	48.9%
Null or Not Rated	262.6	51.1%
Totals for Area of Interest	**514.2**	**100.0%**

Rating Options—Irrigation, General

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change

in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age,

the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of

streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown.

The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2

Low: 0.2 to 0.4

Moderately low: 0.4 to 0.75

Moderate: 0.75 to 1.25

Moderately high: 1.25 to 1.75

High: 1.75 to 2.5

Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^{1}/_{3}$- or $^{1}/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they

form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds

and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0
Coarse sand: 1.0 to 0.5
Medium sand: 0.5 to 0.25
Fine sand: 0.25 to 0.10
Very fine sand: 0.10 to 0.05
Silt: 0.05 to 0.002
Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents

the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated

Prismatic: Vertically elongated and having flat tops

Columnar: Vertically elongated and having rounded tops

Angular blocky: Having faces that intersect at sharp angles (planes)

Subangular blocky: Having subrounded and planar faces (no sharp angles)

Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand

Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.